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### THE HOLLY SYSTEM OF WATER SUPPLY AND FIRE PROTECTION FOR CITIES AND VILLAGES—

Is an invention of Birdsill Holly, of Lockport, N. Y., and was designed not only to supply cities with water for ordinary purposes at any desired elevation, without the use of a reservoir or stand pipe, or any other contrivance for calling into requisition the principle of the hydrostatic equilibrium, but also to furnish the means of extinguishing fires at several points at the same time, if necessary, and all this without the use of any movable engine for that purpose.

This is accomplished by placing a set of Holly pumping machinery within a frost-proof and fire-proof building, located at a convenient point where the supply of water is accessible, and from whence, by a proper system of pipes, the water can be conducted wherever it is needed.

The machinery forces the water directly into the mains, contrivances being provided by which the pressure within the mains may be increased or diminished, or kept uniform at any degree that may be needed.

The pumping machinery must be adequate to the service required, having a reserve of power for extraordinary occasions.

To guard against the contingency of accidents, the machinery is duplicated, and in large works triplicated.

Mr. Holly's first works were established in Lockport for fire protection alone, the machinery consisting of a rotary pump and turbine water wheel, with necessary connections, and a hydrostatic regulator. Three years later he conceived the idea that the same system of pipes could, by adding to the machinery another pump with suitable connections, be made to serve the daily wants of the community, and the feasibility of the combined service was successfully demonstrated and accomplished at Auburn, N. Y., from which time the system has grown in popular favor, until now it is in use in over a hundred cities and villages in the United States, more than seventy of which were furnished with plans and pumping apparatus by the Holly Manufacturing Company.

The Auburn works had triplicate rotary pumps and turbines, and works having similar pumping apparatus were subsequently introduced at Minneapolis, Minn.; Gouverneur, Ogdensburg and Potsdam, N. Y.; Canton, Ohio; and Allegan, Mich.

The rotary pump was also used in connection with high pressure steam engines for water works in Binghamton, Batavia and Syracuse, N. Y.; Peoria and Decatur, Ill.; Kalamazoo, Jackson and Big Rapids, Mich. In these places the matter of fire protection was the first consideration, that of domestic supply and cost of power being secondary.

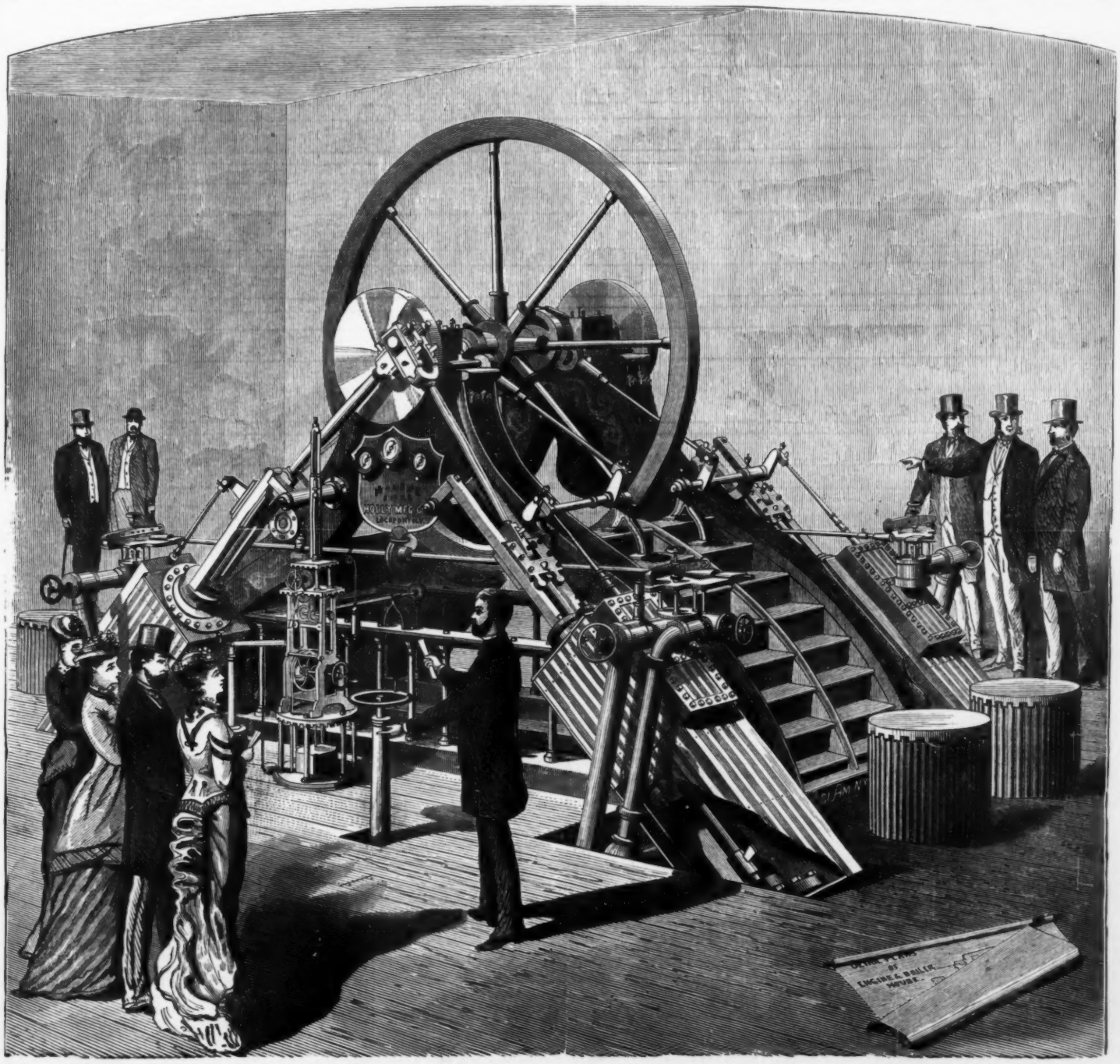
In due time the inventor sought to make such improvements in the mechanism as insured greater economy in the expenses attending daily pumping. The first of these improvements consisted of a series of single acting reciprocating pumps arranged to operate in regular succession, each pump having the lead of that preceding it by one-sixth the length of a stroke, which secured a constant flow of water into the mains. This was called a gang pump, and was designed for domestic supply alone, the rotary pump being in all cases relied upon for the occasional though severer service of fire protection. Some twenty-three water works were supplied with this pump with satisfactory results.

The second important improvement was made in 1871–2, when a direct acting, condensing, steam pumping engine, similar in general construction to the compound engine hereafter described, was erected at the Dunkirk, N. Y., Water Works.

This engine was adapted to both domestic and fire service, and made it possible to dispense with the rotary pumps in some instances.

The third important improvement in the pumping machinery was the addition to the last mentioned engine of appliances for compounding steam. This was first introduced at the Rochester, N. Y., water works in 1873–4, and subsequently at the works in Binghamton, Buffalo, Flushing and Garden City, N. Y.; Titusville, Penn.; Sacramento, Cal.; Bay City and Port Huron, Mich.; Hyde Park, Evanston and Rockford, Ill.; Taunton, Mass.; Burlington and Keokuk, Iowa; Dayton, Columbus and Urbana, Ohio; Indianapolis, Ind.; Kansas City, Mo.; Pueblo, Colorado; and Atlanta, Georgia.

Following is a general description of this *Holly Compound Pumping Engine*, which is the subject of our illustration.



HOLLY'S NEW PUMPING ENGINE AND AUTOMATIC PRESSURE REGULATOR.

The engine consists of four steam cylinders, having four corresponding reciprocating pumps attached by direct connections, and erected on a heavy arched double frame of iron, set at an angle of 90°, one steam cylinder and its pump being placed at each of the four corners. The frame supports at its top a shaft with an overhanging crank on either end, to which the four engines are connected by ordinary connecting rods. The cylinders and pumps are detachable at pleasure, and may be run singly, in pairs, or all together, according to the demands for water supply. The engine is provided with the usual air pump and jet or surface condenser, and by a peculiar arrangement of pipes and valves may be run on either the high, low, or compound steam pressure principle, and may be changed from one to another at any moment, by the engineer. This arrangement is necessary to secure economical daily pumping for domestic supply, which is done by compounding steam, and prompt increase of power for efficient fire protection, which is amply secured by converting the machine into a high pressure engine. When compounding, the steam is taken directly from the boilers into one of the cylinders and exhausted into the remaining three; and when running high pressure, steam is taken directly into all of the cylinders, the latter operation increasing the power of the whole, four to eight times. To supply this increase reserve boilers are provided, and to guard against a failure in the water supply duplicate engines are added when the demands of consumers equal one-half the capacity of the engines first erected.

The Direct Pumping Service, we are informed, requires, to make it efficient and economical, the following highly important features in the pumping apparatus:

1. Ample power to meet the extraordinary demands for water for fire protection. 2. Duplicate engines, pumps and boilers, as a provision against accidents. 3. Economy in daily running expenses. 4. Uniformity of water pressure. 5. Prompt increase of pressure for fire protection.

All these conditions are fulfilled by the engine just described in connection with

THE HOLLY HYDROSTATIC AUTOMATIC REGULATOR,

for controlling the water pressure in the mains and pipes of water works, which next to the engines and pumps is the most important feature of the Holly system of water supply, and is essential to securing the following results:

1. Uniformity of water pressure. 2. Economy in the use of fuel. 3. Relief to the machinery, mains and service pipes from "water hammer," and the strain of unequal pressure. 4. Relief to the engineer from almost constant attention at the throttle valve. 5. Saves the wages of one man.

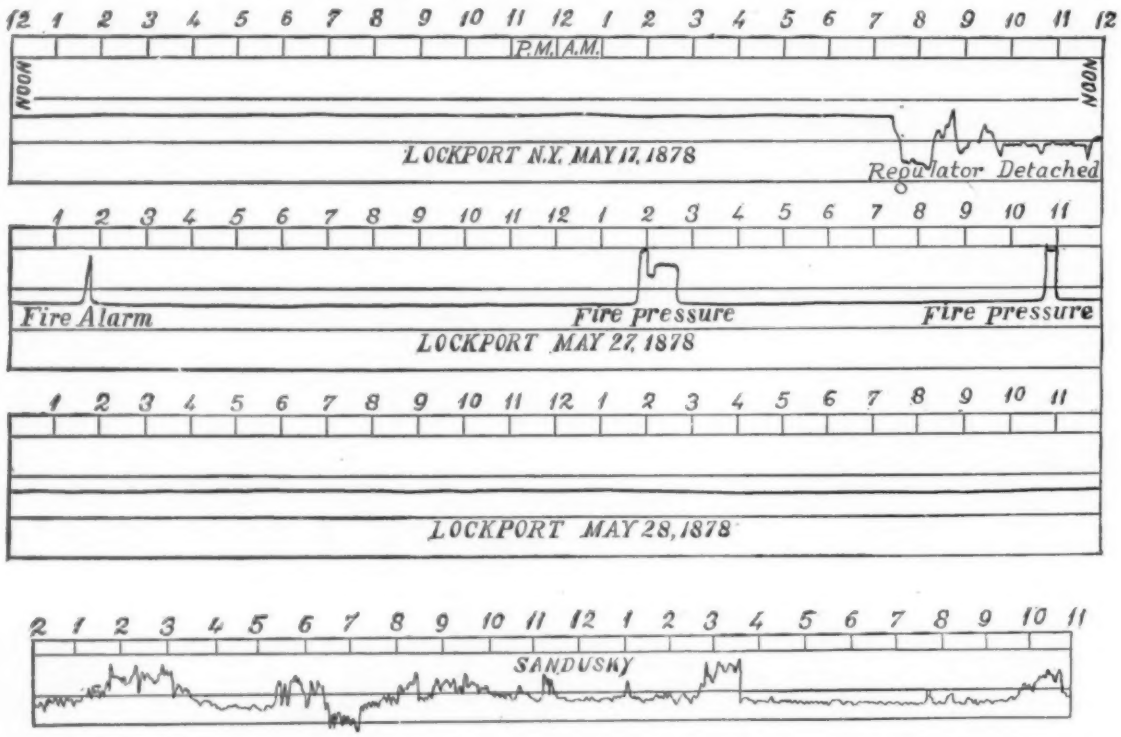
The Regulator is provided with a piston, placed within an upright cylinder, and having a rod extending upward which is connected to a cross bar, having heavy weights, which by means of suitable contrivances bear down upon the piston with a force that increases as the piston rises. A small pipe connects the water mains with the cylinder below the piston, and any change in the water pressure (which would be increased or diminished by opening or closing service cocks) at once communicates motion to the piston, and the force below the piston is always met by an equal resisting force from the increasing weight. By means of simple appliances, the changes in the position of the piston are utilized to operate on the steam valves of the engine (or the gates of a water-wheel, if works are run by water power), and change the point at which steam is cut off in the cylinders of the engine, thereby increasing or decreasing the power of the engines, the speed of the pumps, and the quantity of water supplied. Thus it will be seen that if the piston moves either higher or lower in the cylinder than the point at which it may have been set to maintain the desired pressure, it will automatically bring the speed of the engine to the rate required to supply the demands for water, and permit the pressure to vary only within the limits needed—two or three pounds—to reverse the action of the cut-off moving mechanism of the regulator.

We here reproduce cards made by an Edson's "recording gauge," showing the action that the regulator has on water pressure.

The diagram dated May 17th was taken from the Lockport Water Works, with the regulator detached from 7:30 A.M. until noon. It will be noticed that the extremes of pressure with the regulator attached are within a range of five pounds, while without the regulator the variation is 35 pounds. The diagram marked "Sandusky Water-Works" was published by parties opposed to direct pumping to show the alleged imperfections of the Holly system. The Sandusky works are on the stand pipe plan, with duplex pumping machinery. This card was taken with the stand pipe disconnected, and the water pumped direct to the city. The only means that could be used to regulate the pressure was the engine throttle valve operated by the attendant. The similarity between this card and the irregular portion of that dated May 17th shows that the system of direct pumping needs some contrivance that will by automatic action maintain a nearly uniform pressure. The differences shown by the diagrams demonstrate the usefulness of the Holly regulating devices.

The maintaining of uniform pressure is of further utility, as it operates to lessen the consumption of coal, by preventing an undue increase of labor on the pumps, such as would result from attempting to carry a fluctuating pressure sufficient to supply the highest portions of a city at all hours. To illustrate, suppose that it is required to force the water to an elevation of 100 feet to supply the most elevated buildings, and that the extremes of pressure from a non-regulated pump have, as the diagrams show, a range of 76 feet head (or 35 pounds). It is plain that if the pressure be allowed to go below 100 feet the highest buildings will not be supplied, and that to maintain the supply the fluctuations of pressure must range wholly above that point. Under these circumstances the actual pressure would be by average 36 feet (36 per cent.) greater under the non-regulated direct pumping than under the Holly plan, which would require a corresponding increase in fuel and strength of machinery, and cause greater strain and wear upon all parts of the works.

It has been a problem of considerable difficulty to design an engine which would meet all the requirements of the direct supply system, and at the same time produce economical results as regards coal consumption. Mr. Holly during his long experience with this system has noted all its defects, and by ingenious contrivances and peculiar methods of construction has remedied them, so that the Holly Company is now prepared to guarantee results in coal consumption, while pumping direct, that will exceed any that can be produced by a duplex pumping engine while pumping into a stand pipe or reservoir, or better results when pumping into reservoir or stand pipe, than with a duplex pumping direct.




Referring again to the Holly compound engine, it is desired to call special attention to the facility with which the pumps may be connected or disconnected to meet the extremes of domestic and fire service. As before stated, the latter requires a supply four to eight times greater than the former, and when the demand for an increase is made the response must be prompt and sure. This can only be insured by providing machinery of sufficient capacity to meet the larger demand. A single engine is objectionable, because the slow rate at which it must be run for the domestic supply makes it impossible to secure economical results in the consumption of fuel, it being a well-known fact that any engine will give the best results when operating at its full capacity and a steady rate of speed. The desired results may be best secured by using several pumps of smaller size, but they should all be connected so as to insure their working in harmony, else the flow of water will not be uniform.

The Holly engine is practically a combination of four engines in one, but so arranged that either or all of them may be used at pleasure, and connected or disconnected in one to three minutes without interrupting the water supply.

This arrangement of pumps has, as intimated, an important bearing upon the matter of duty, especially in new works, where the domestic supply for a few years will be small. For instance, an engine of 2,000,000 gallons daily capacity, using four pumps, would be run at the rate of, say, twenty-four revolutions per minute to pump the full quantity. During the first year the daily demand would not exceed, say, 500,000 gallons, to supply which the four pumps would be run at only six revolutions per minute—a rate much too slow for the economical use of steam, but by disconnecting three of the pumps the full rate of twenty-four would be maintained with correspondingly favorable results.

It should be remembered that the Holly engine is arranged to compound steam by taking it direct from the boiler into one cylinder, and exhausting into the remaining three, thence into the condenser, and that when operated in this manner the most economical results in pumping the daily supply are secured. But when so operated it has not sufficient power to meet all the requirements of fire service, so provision is made for increasing the power by converting it into a condensing or low pressure engine, live steam being then taken into all of the cylinders at partial or full length of stroke, as may be necessary. In case the air pumps or any part of the condensing apparatus become disarranged, they may be disconnected and the engines run on the high pressure principle. Thus it will be seen that the economic results due to a compound engine, and the greater power due to the condensing and high pressure engines, are both secured in this latest improvement of Mr. Holly.

An attempt to accomplish equal results in economic daily running and effective fire protection with a large compound engine of sufficient power to perform the latter service would fail in securing the former, for the reason before given, that an engine must be constantly used at its full capacity to secure the best results.

*The chief merits and advantages of the Holly System are that it—*

1. Secures by variable pressure a more reliable supply of water for all purposes. 2. Less cost of construction. 3. Less cost for maintenance. 4. Less cost for daily supply by the use of Holly's Improved Pumping Machinery. 5. Affords the best fire protection in the world. 6. Largely reduces insurance risks and premiums. 7. Dispenses with fire engines in whole or in part. 8. Reduces fire department expenses.

A great mass of undisputed evidence could be presented in verification of these claims, but it is deemed unnecessary, because the Holly system has become generally known throughout the country, and its successful operation in seventy cities and villages has long since established the fact that it is no longer an experiment, but one of the greatest inventions of the age.

The idea has been industriously circulated that the Holly plan is only suitable for small places, and on a small scale, when, in fact, it is susceptible of enlargement to meet fully the wants of the largest city on the face of the globe. This enlargement may be accomplished either by increasing the size of machinery, or by multiplying sets of machinery, or both of these modes combined, and with corresponding enlargement and extension of street mains. It also provides for supplying water at higher elevations and longer distances than can be done with works on any other plan.

The Holly system, like all other important inventions, has met with vigorous opposition. Some came from persons having honest differences of opinion as to its practicability, much from men who opposed without fully investigating its merits, and more from parties whose pecuniary interests were more or less affected by the success of the new plan.

The crowning proof of the merits of Holly's Water Works is found in the fact that in several instances parties are striving to imitate the plan which Mr. Holly has devised, perfected and secured to himself and associates in the Holly Manufacturing Company by numerous letters patent. It is alleged that this may be done without incurring legal liabilities for patent infringement, because Holly's plan is not new, but was in use in London some three hundred years ago and in other places at later dates. In order to test the validity of Mr. Holly's claims, the first two cases of infringement were promptly taken up and carried into the courts; one was against the city of Rahway, N. J., and the other the city of Union City, Ind. It was decided to make the latter the test case, and a vigorous contest extending over a term of more than seven years ensued. It was finally decided in June last, by Judge Drummond, in favor of the Holly patent, as will be seen by extracts from the decision given below.

In order that the question at issue may be clearly understood the following quotations from the letters patent are given:

Mr. Holly says in the specifications: "I do not pretend to have been the first to conceive the idea of furnishing water in limited quantities for ordinary use by means of forcing pumps; nor do I deny that stationary pumps have been employed instead of movable ones in throwing water for the extinguishment of fires; but my invention consists in effecting these two objects by one single apparatus, and then developing that apparatus into an effective system for the attainment of these ends. This is accomplished by pumping the water directly into the mains of the water works, having made provision by which the degree of pressure therein may be entirely under the control of the operator, so that it may be preserved uniform or increased or diminished in any degree at his pleasure. By this means the apparatus which with one degree of pressure may be serving as a means of supplying water to a whole city for ordinary use may, by simply increasing that pressure, become at the same time a

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most effective fire engine, which through hydrants previously and properly located may be made to operate in various portions of the city at the same time, and (owing to the great incompressibility of water) this change can be effected almost instantaneously throughout. This is the subject matter of my invention."

This first claim, upon which the suit was founded, reads as follows:

"1. The above described method of supplying a city with water—that is to say, by pumping directly into the mains when the apparatus for that purpose is supplied with contrivances by which the pressure within those mains may be preserved in a great degree uniform, sufficiently so for practical purposes, *or increased or diminished at pleasure*, substantially as and for the purpose above shown."

The following extracts from the decision of the Court embrace the points of general interest:

"That the letters patent No. 5,132, reissue, on the first claim of which the present suit is founded, are good and valid in law; that the method of supplying a city with water, as described in said first claim, is the invention of said Holly, and that the said claim is not anticipated by any of the prior patents and uses pleaded in this case; that the defendant has infringed said letters patent, and an injunction is therefore ordered to restrain the defendant from making, using, or vending any system of water works whereby the water is pumped directly into the water mains, the apparatus for that purpose being supplied with contrivances like or substantially like those shown and described in said reissued letters patent, by which the pressure within the mains may be preserved in a great degree uniform, sufficiently so for practical purposes, *or whereby it may be increased or diminished at pleasure*, or from in any manner infringing upon or violating any right or privilege granted or secured to the complainant by the said reissued letters patent."

After the success of the Holly Water Works had become assured, various parties, some of whom were unwilling to fully acknowledge its advantages, and others who desired to evade the Holly patents, devised and suggested several modifications and compromises between it and the older systems of water supply, all of which were designed "to enable the operator to increase or diminish the water pressure at pleasure." These devices may be classed under the following heads:

1. The use of gates for shutting off the reservoir or stand pipe, and an auxiliary main through which the water might be pumped direct in case of fire or other emergency.

2. The erection on the top of a stand pipe of a tank, of sufficient size to contain a few hours' supply of water, by way of avoiding constant pumping, and having gates and direct main, as above, for fire supply.

3. The construction of an exceedingly large stand pipe or iron reservoir for domestic supply, with a small internal stand pipe of greater height for fire pressure; also with gates and direct main, as above.

4. A stand pipe with partially closed top, having a valve by which it could be closed entirely to prevent overflowing when pumping direct for fire pressure, and which, when closed, would serve as a huge air chamber.

5. A large iron air chamber, called by the inventor an "accumulator," filled with compressed air, which was to be turned on to the water mains so as to quickly increase the pressure sufficiently to throw five streams directly from the hydrants. In this case the water was to be pumped direct for all purposes.

Following is the record of the Holly Compound Pumping Engine, as regards duty, or pounds of water raised one foot by the engine, with a consumption of one hundred pounds of coal under the boilers:

| Place. | Date of test. | Duty in foot pounds. | Authority. |
|---|---|---|---|
| Rochester, N. Y. | July 9, 1874 | 63,309,107. | J. E. Booth & F. H. Clement. |
| Evanston, Ill. | Mar. 24, 1875 | 54,990,024. | J. R Fitch & L. E. Cooley. |
| Atlanta, Ga. | Sept 28, 1875 | 60,403,800. | R. T. Scowden. |
| Binghamton, N.Y. | Mar. 6, 1876 | 81,514,000 | John Evans. |
| Indianapolis, Ind. | April 6, 1876 | 76,257,848 | W. Bellis & W. G. Hamilton. |
| Taunton, Mass. | Dec. 26, 1876 | 49,045,944* | Geo H. Bishop. |
| Taunton, Mass. | Dec. 28, 1876 | 75,117,514 | Carlos Holly. |
| Hyde Park, Ill. | April —, 1878 | 65,258,700 | E.S. Chesbrough & J.D.Cook. |
| Burlington, Iowa | May 30, 1878 | 71,514,000 | T. N. Boutelle. |
| Keokuk, Iowa | July 18, 1878 | 62,334,439 | W. C. Stripe. |

In all the tests no allowance was made for cinders or ashes, excepting at Burlington, where, on account of inferior quality of coal, twenty per cent. of the refuse was deducted.

The average cost of pumping one million gallons of water one foot high with Holly engines during the past year was, according to official reports: In Binghamton, N. Y., $7\frac{5}{16}$ cents; Rock Island, Ill., $8\frac{7}{16}$ cents, and Atlanta, Ga., $9\frac{4}{16}$ cents. This includes repairs and all other expenses pertaining to the pumping departments.

As a system of fire protection there can be no doubt this is the best. It makes every hydrant a powerful fire engine, which can be used to put out fires more successfully than by the movable engines which must be used in connection with gravitation works. Under the Holly system there are increased barriers against large conflagrations, and protection against large and fearful losses. We are informed that underwriters recognize the introduction of this improved method of fire suppression as a reason for reduction in insurance rates.

An astonishing fire stream display was given at the trial for acceptance of the Holly Works, in Rochester, N. Y., in February, 1874, which may appear almost incredulous, but the statements here made are vouched for by no less than nine civil engineers and surveyors, who were stationed at different points to measure the height of the streams. We summarize the result of the test as reported as follows:

1st. Thirty streams from 1-inch nozzles through single lines of hose attached to the hydrants were thrown to the height of 135 feet. 2d. One 2-inch stream supplied by three leads of hose attached to a discharge pipe, having triplicate couplings, was thrown 230 feet high. 3d. One 3-inch stream from a special attachment to one of the principal water mains was forced 285 feet high. 4th. One 4-inch stream was forced 297 feet high and 465 feet horizontally. 5th. One 5-inch stream was thrown 250 feet perpendicularly.

For further information address the Holly Manufacturing Company, Lockport, N. Y.

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TERRIFIC cloud bursts are common in the Black Hills, where one recently inundated a large tract of farming country, sweeping away ox teams and drowning one man. They have also done much damage to the track of the Union Pacific Railroad.

* The first test at Taunton was made with the engine pumping only one third its rated capacity.

## ROCK BORING MACHINERY.

AN admirable sketch of the history and characteristics of rock-boring machinery is given in an interesting pamphlet by Mr. Richard Schram,* whose own invention for a rock drill was referred to in the *Mining Journal* a few weeks since. He remarked that during recent years the success attending the introduction of rock-boring machines for accomplishing various engineering works had induced many to decide upon substituting machine work for hand labor in drilling for the purpose of blasting in mining and excavating operations. Some difficulties have been encountered in selecting a machine precisely suited for the particular work in hand, and thus a certain prejudice against the use of these machines in general has not unnaturally been created.

Referring to the causes which have led to rock-boring machines not having proved wholly successful, Mr. Schram is of opinion that it will be found upon inquiry that it is because their practical working has not been properly understood. Experience teaches us, he remarks, that in the employment of rock boring machines it is as essential that the whole system of operations be sound and well planned as that the machines themselves be effective and simple, so as not to require much or frequent repairing. Upon the first introduction of rock-boring machines old experienced miners were employed, and it was quite natural that they should endeavor to give the holes such directions, and proceed generally as nearly as possible in the same manner, as they had been accustomed to do in hand boring.

If, however, we glance at the progress of any other branch of industry, we shall find that a more systematic method of working has invariably been the consequence of the introduction of machinery, and that to the improved organization and regularity thus accruing must be attributed no inconsiderable part of the great and manifold advantages of all machine work over hand labor. Rock boring by machinery forms no exception to the industries obeying this general law of progress, and upon its introduction rational systematic methods of working must be adopted. At the present time there is scarcely any branch of industry in which machinery does not play an important part. In some branches the mechanical appliances are so perfect that it would be impossible now to dispense with them; in others, on the contrary, the machines may be said to be in their infancy. To this last category rock boring has hitherto belonged.

The idea of using machinery in rock drilling was, Mr. Schram tells us, entertained long ago. In 1844 Burton, an Englishman, suggested the idea of employing compressed air to work a hammer striking upon a drill, but no practical support was given to the suggestion; and it was in the year 1854 that Bartlett, also an Englishman, and in 1855 that Schumann, of Freiberg, first appeared before the public with practical experiments. From these dates down to the present time improvements and developments in rock-boring machinery have succeeded one another with great rapidity. Mr. Schram ranges the existing rock-boring machines into five classes—the ram system, embracing the Schwarzkopff and Warsop drills; the lever system, embracing Schumann's, Burleigh's, Sach's, McKean's, Warrington's, Ingersoll's, Dunn's, Roanhead, Cranston, Barrow, and many other machines; the duplex system, embracing the machines of Sommeiller and Ferroux; the rotary system, embracing the diamond drill, Brandt's, etc.; and the direct acting system, including Darlington's, Schram's, and Reynolds', without slide, and Osterkamp's, Schram's, Cederblom's, and others with slide.

Discussing the merits of the several systems, Mr. Schram remarks that the ram system as applied to rock-boring machines must prove impracticable, and must be so apparent to every one who has seen a worn-out hammer and hand drill that it is unnecessary to give it any consideration. The lever system has, he says, long kept its place, and several machines constructed upon this system have done very good service, but he considers the disadvantages of the system are the great wear and tear to which the machines must be exposed, and the unpreventable loss of power, results which he regards as inseparable from a mode in which levers or tappets are actuated by the piston.

The duplex system has, Mr. Schram states, only been employed in places where compressed air has been cheap and plentiful, as in the Mont Cenis and St. Gothard Tunnels, but in either of these places machines of a later invention would have been found to work both better and more economically. By employing a separate engine to work the slide, the piston which carries the cutting tool runs perfectly free, and as these pistons are made of a large diameter and have a long stroke, the machines are consequently very powerful. But in proportion to their great consumption of compressed air (first in the subsidiary engine and again in the main cylinder) they prove very expensive in working. Moreover, in consequence of the great length of the machines, the holes must all be bored in a nearly horizontal position, thereby necessitating the use of a greater amount of explosive for blasting than would otherwise be necessary. The rotary system, as carried out for blasting operations, has likewise met with very limited approval.

It is true that Lisbeth's rotary hand drill, as improved by Macdermott, works admirably in coal and soft slate, and no doubt the employment of these machines in coal mines is already extensive, and is rapidly spreading, but they are by no means adapted for the harder varieties of rock. Mr. Schram admits that for prospecting purposes the diamond drill is no doubt extremely valuable. One of the advantages held out in favor of rotary rock drills is that they are incessantly working into the stone, a condition evidently incompatible with any percussive action; but, on the other hand, the force of each blow of a percussion machine is very much greater than the force which in a rotary machine is constantly exerted. Moreover, the constant resistance to which the tool of a rotary drill is subjected necessitates a greater motive power, and, after all, the actual work done is less than that of a percussion machine.

An interesting trial of a rotary rock-boring machine invented by Brandt was made in 1877 in the Sonnenwendstein Tunnel, on Ebensee, in Austria. On the shore of the lake Ebensee an engine house was built, in which was erected a steam engine with two steam cylinders, each 24 centimeters in diameter. Water under a very high pressure (stated to be 70 atmospheres) was carried in strong wrought-iron tubes into the tunnel, where it worked the rock-boring machines. These consisted of two auxiliary cylinders, acting upon a crank shaft laid at right angles across the drill, and a worm cut in the middle of this shaft caused the drill to rotate. The central part of the machine formed a cylinder, in which was fitted a plunger piston attached to a joint, by means of which the machine was connected with a very strong stretcher or standard. Water being admitted to this cylinder, and exerting its force against the plunger, pressed the whole machine forward toward the rock, and thus maintained an enormous pressure on the cutting tool as it rotated. In the extreme end of the drill, which was hollow, there was a steel crown furnished with teeth, which, through the rotary motion and the great force with which the apparatus was pressed against the rock, cut the stone in a similar manner to the diamond drill. Water was employed to clear out the debris from the holes.

The drill made 30 revolutions per minute, and, boring holes of 7·5 centimeters diameter, it progressed at the rate of 3 centimeters per minute. The rock was dolomite. As great difficulty was experienced in commencing the holes, they were bored double their required depth—that is to say, double the depth at which the explosive proved to be effective, and before being charged and fired were filled up for half their depth with sand. After the first charges were fired the sand was removed from the remainder of the holes, which were then charged and fired again. The heavy expenses of working proved too great for the general adoption of this machine in other places.

As belonging to the direct acting system without slides, Mr. Schram has mentioned the Darlington, Reynolds, and Schram machines. Simple as this system is, it is, he says, nevertheless unpractical, because the piston being propelled by expansion, the pressure is consequently least when it ought to be greatest—*i. e.*, at the end of each stroke. Another defect is that pressure is exerted on the lower side of the piston during the forward stroke, thereby counteracting the force of each blow to a most injurious degree. The Darlington machine especially requires twice the quantity of compressed air necessary for most other machines of the same size, notwithstanding which the effect in boring horizontal holes is over 100 per cent. less than in the case of machines of more modern construction. He describes one of his own machines of this class, but remarks that this system, simple as it is, is by no means practicable, as, though the machine will run at an extraordinary high speed, the boring results, as compared with the direct acting machines with slide, are not satisfactory.

In the class of direct acting machines with slides are those by Osterkamp, Dœring, Schram, Cederblom, and others; and he here describes his own arrangement, which has certainly much to recommend it. The only moving parts of the machine are the main piston, the slide piston and slide, and the rotating movement with its piston. It is an important feature in this machine that the slide rod is made in the form of a double spindle valve; by this method of construction it remains in position without any recoil until the piston has made the greater part of its stroke. As in some varieties of rock it happens that the drill often sticks fast, there is a reversing rod to suddenly reverse the slide, and thus pull the drill out of the hole. With careless workmen it would frequently happen that the piston would strike against the lower cylinder cover, therefore there is an air cushion at the lower end of the cylinder. In addition to this there are an iron ring and an India-rubber washer (exchanged for one of wrought iron when steam is used), with the object of moderating the violence of the shock such blows, inadvertently permitted, would cause. In order that the hole drilled be perfectly round, it is necessary that the cutting tool should partially rotate at each backward stroke so that its cutting edge shall every time strike the rock in a fresh place, but in order not to lose any power it must always make its forward stroke without rotating. For this purpose a twisted bar is employed, connected with a grooved disk, and a brake acted upon by a small piston. Communicating from the slide box with the cylinder is a small port, by means of which the compressed air exerts a constant pressure upon the upper end of the small piston. When the main piston makes its backward stroke the back end of the cylinder is in communication with the outlet, and consequently there is no pressure on the lower end of the small piston.

The constant pressure on the upper end of this piston, therefore, now presses it upon the brake which presses upon the disk, preventing it from turning, and thus the main piston is forced to partially rotate round the twisted bar secured to the disk. But when the main piston makes its forward stroke, and steam or compressed air fills the back end of the cylinder, the motive fluid enters through small ports and presses on the lower end of the small piston, thus counterbalancing the constant pressure on the upper end. There being now no pressure on the brake the disk is free to rotate, and the main piston makes its forward stroke without rotating, partially turning the disk as it proceeds by means of the twisted bar.

This machine is sometimes made with an automatic feed motion actuated directly by means of a piston, instead of, as in other rock-boring machines, through levers, but the inventor nevertheless recommends in all cases a manual feed, as, notwithstanding all the assertions to the contrary of eager rock-boring machine dealers, practical miners know that in some faulty rock the drill will and must occasionally stick fast. When this happens it takes much longer time to clear the cutting tool, if an automatic feed is in use, than in simply giving the handle of a manual feed a turn or two, which is all that is necessary to loosen the drill and permit of the boring being proceeded with. Moreover the workmen are never so attentive to their work when they have nothing to do but to look on as they are when they have the machine constantly under hand. Thus, apart from the increased complication and greater wear and tear to which even the best automatic feed motion renders any machine liable, such a feed has always been found objectionable in actual practice.

Through the perfectly free action of the main piston, and because the motive fluid is admitted to the whole surface of its upper end, each blow is extremely powerful; moreover this free action, combined with that of the slide piston, allows the machine to be run at a very high speed, and enables it to be worked with a very low pressure. Its principal feature, however, is its remarkably small consumption of compressed air, as an air compressor which would only be able to drive one machine constructed on the lever system will easily drive two of Schram's, the diameter of cylinder being the same in both cases. There being no parts exposed to blows, and the principal parts being directly actuated by the motive fluid, this machine is less liable to wear and tear than those of other systems. It should also be observed that the working parts are all inside the cylinders, so that rough-handed miners, unaccustomed to use more fragile instruments than sledge hammers and picks, may be safely intrusted with the handling of these rock drills.

Reverting for one moment to the slide action, it may be mentioned that this machine was at first constructed with a cylindrical slide, but considering the leakage of motive fluid

* "The Application of Machine Power in Rock Drilling." By Richard Schram. London: G. Hill, Westminster Bridge-road.

caused by wear and tear which has always been found to result from the employment of this form of slide in steam engines, the inventor has considered it most practical to adopt the old form of D slide, which has this great advantage, that even after years of work it always fits perfectly tight on to the slide face.

The supports and various other details connected with machine drilling are referred to at equal length; but as these will constantly vary with the work in hand, an abstract of Mr. Schram's remarks would be of little value; the book itself, which is really worthy of careful reading by all practical men, must be referred to for further information on the subject.—*Mining Journal.*

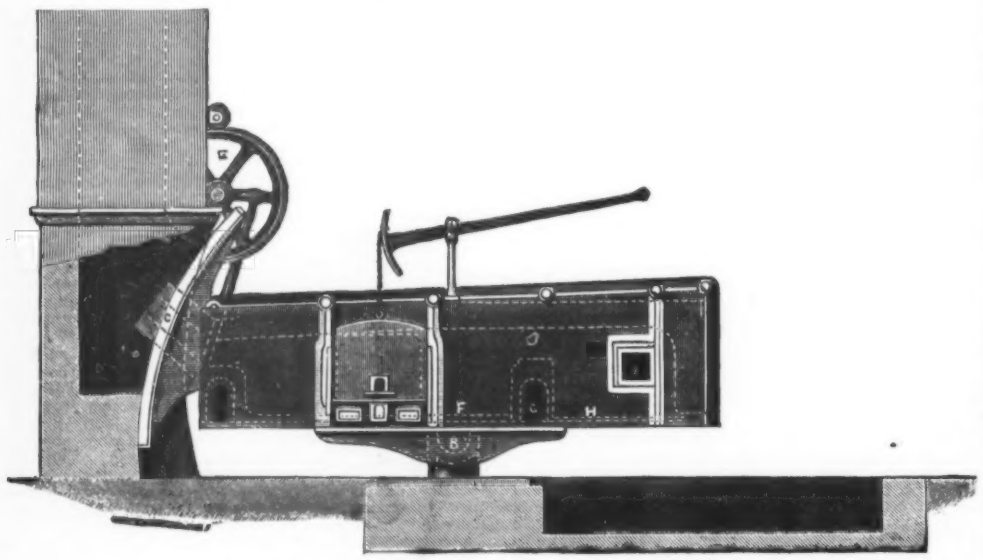
## THE ABBOTT PUDDLING FURNACE.

THE furnace consists essentially of a reverberatory furnace, differing but little in construction from the furnaces in general use, and it can be at once taken charge of and worked by any puddler without further instruction; the essential feature of novelty being that the furnace is mounted on an axis and is free to rock or oscillate. The rocking or oscillating motion is given by a small engine, and a neck with a curved end is provided to keep up an open communication between the furnace and the chimney or flue during the oscillation, so that the products of combustion may be free to escape.

The figure shows a side elevation, with section partly marked, of one of my furnaces. The body of the furnace is supported so as to be free to rock on the bearings, *b*; *c* is the curved neck which fits against the chimney, *d*; *e* is the gearing by which motion is giving to the furnace, *f* is the hearth which contains the metal being puddled, *g* are hollow bridges kept cool by air or water passing therethrough, *h* is the firegrate, *i* is the door through which the furnace is charged and the blooms removed, *j* is the firing door.

After the fettling and cinder are placed in the hearth in the usual manner, the furnace is charged with iron and is then ready for action.

The furnace is first inclined so that the heated gases and products of combustion from the fire-grate shall strike directly against the metal in the hearth before passing to the chimney, and thus cause it speedily to assume the molten state. As soon as the metal is in a molten condition the furnace is caused to oscillate slowly, from six to eight oscillations a minute being sufficient, the greatest angle which the hearth assumes out of the horizontal being about 30°. The oscillating motion causes the iron to flow from one end of the hearth to the other and strike against hollow bridges provided at each end and kept cool by air or water. The iron while flowing backward and forward acquires a sort of undulating or wave-like motion, so that every portion of the mass is brought into contact with both the fettling and with the heated gases and products of combustion passing through the furnace. The oscillating motion also assists the balling if the puddler only takes advantage of the motion of the furnace. The operation of puddling in this furnace occupies from 40 to 60 minutes.



THE ABBOTT PUDDLING FURNACE.

The puddled balls when they are removed from the furnace appear to be almost free from cinder, and require but little manipulation under the hammer to make them suitable for the mill furnace. In fact, iron as it leaves the furnace appears to be perfectly homogeneous, and may be produced in various conditions, from that of soft malleable iron to that of steel, which, by the addition of manganese during the operation, may, I have no doubt, be obtained of any desired quality. With the small furnace with which I commenced operations, 4½ to 6 cwt. of cast iron was heated at one time, and I was able to obtain eight heats in twelve hours, in one case a heat having been got out within the hour.

The furnace illustrated will puddle 15 cwt. of iron at each operation, and the wear and tear is less than in an ordinary furnace.

Mr. Abbott, with the aid of a model, explained various matters connected with the working and construction of the furnace. He said that, with the small furnace they had in operation, eight heats could be got in twelve hours, and they were enabled to produce about 50 cwt. of puddled iron in that time, whereas from an ordinary furnace of the same size only 25 cwt. could be obtained. There was also no heavy expenditure for labor.

Mr. Thompson said that he understood that a great many schemes for the accomplishment of similar results had proved failures; how was it, then, that the present plan should prove successful when the difference was so very slight?

Mr. Abbott explained that the principal reason of the success was that the moving and wearing parts were outside the furnace, and that there were no openings through which cold air could enter except in the usual manner.

Mr. Thompson said that the new plan appeared to consist in causing the firegrate to vibrate with the furnace.

The President inquired what the difference in cost per ton was between iron produced in the ordinary way and that manufactured by the new process.

Mr. Abbott stated that they could produce and sell iron at £6 10s. per ton equal to that for which £10 to £12 was now paid. In fact, they could produce iron equal to the best Lowmoor from the common pig, the quality of the produced iron being always uniform, the quantity alone varying with the kind of pig used. He also stated that the same quantity of fuel was used as in an ordinary furnace, but that double the quantity of iron was produced; the fettling, moreover, was very little affected, and the bottom of the furnace always remained smooth and in good condition.—*Iron.*

## LOCOMOTIVE VERSUS HORSE POWER.

AN inquiry of no little interest is followed by Edward Appleton in a paper recently read before the Boston Society of Civil Engineers. He cited authorities by which a comparative estimate of locomotive and horse power can be made. A nominal horse power is that necessary to raise 33,000 lbs. 1 foot high per minute, an estimate first made by Boulton & Watt in selling their steam engines. Trautwine says that his assumption can really be carried out by a strong horse day after day for eight or ten hours; but as an engine can work day and night without stopping, while a horse cannot, a one-horse engine can do much more work than any one such horse. Boulton & Watt meant that their one-horse engine could at any moment perform the work of a very strong horse. Trautwine estimates that a good, average trained horse, weighing about half a ton, well fed and treated, can walk ten hours per day at the rate of 2½ miles per hour on a good level road, and exert a continuous pull or tractive force of 100 lbs. On a level piece of good road he estimates the traction at 60 lbs. per ton of load and carriage; so that the 100 lbs. of tractive force exerted by the average horse enables him to pull a load of 1⅔ ton at the rate of 2½ miles per hour for ten hours per day on a good level road. Trautwine gives the weight of a train, exclusive of engine and tender, which a good locomotive, weighing 27 tons, or 60,480 lbs., all on the drivers, can haul on a level railroad, at a moderate speed, say eight to twelve miles an hour, as 1,458 tons, an estimate corresponding very nearly with the amount of work which the Baldwin Company guarantee their locomotives of similar size to perform. This locomotive, then, will haul a load as heavy as 878 horses could pull at the rate of speed assumed above for them on good common roads; but as it hauls this load at an average speed of four times that of horses, it is doing the work of 3,512 horses, and is capable of doing it, not merely for ten hours per day, but for nearly the whole twenty-four hours. If the horses, however, were hauling upon a level railroad instead of a common road, it would not require so many of them to do the same work. Haswell gives a table of the comparative useful effect of the power of an average horse on a turnpike, a railroad, and a canal. He rates the tractive force of the horse at 83·3 lbs., and says that a horse traveling at the rate of 2½ miles per hour for 11½ hours per day will exert a useful effect equal to 14 tons drawn one mile on a turnpike, 115 tons on a railroad, and 510 tons on a canal. Making the hours of work and the tractive force agree with those of Trautwine, the average horse would draw 110 tons one mile on the railroad, or for his whole distance of 25 miles in 10 hours he would draw 4 and four-tenths tons. The locomotive above described then draws as many tons as 331½ horses could pull on the same railroad, and as it draws them at four times the speed of the horses, it does as much work in the same time as 1 325 horses.

## PROGRESS OF ARTILLERY.

THE progress of artillery has of late years advanced by a series of leaps, and one of the greatest of them is at this moment being taken. Not only has the size of great guns been suddenly troubled by the advent of the 100-ton pieces supplied by Sir W. Armstrong's firm to the Italian and English Governments, but guns have been and are now being made which, weight for weight, have double the penetrating power of their predecessors, and the special feature of the new guns is that the high velocities of their projectiles are obtained without any undue strain on the piece. We have not space to go thoroughly into the whole question, but may give details enough to make the subject clear, at least to those who understand something of the art of the artillerist.

It will be remembered that 64 rounds were fired at Spezia toward the end of the year 1876 from the 100-ton gun supplied to the Italian Government, that the guarantee of the makers was much exceeded, and that the gun was then returned to them to be chambered—that is, to be enlarged at that part of the bore which contains the powder charge, in order that a still higher power might be developed. During March and April of this year, experiments have been made at Spezia to the extent of firing 35 rounds with the chambered gun. The object of the trials was threefold—first, to obtain the ballistic data for the chambered gun with English powder and compare them with the same data for the unchambered gun; secondly, to try the Italian Fossano powder, which was described in the *Times* of the 5th of January, 1877, and compare its action with that of the English powder as used for the heaviest ordnance and known as P2; thirdly, to determine the best form of cartridge and means of igniting it.

The results with reference to the first question may be summed up as follows: Taking the proper charges for the unchambered and chambered guns, fired in each case with a projectile weighing 2,000 lbs., the initial velocity of the former was 1,424 feet per second, the energy of the shot 28,130 foot-tons, and the pressure inside the powder-chamber—that is, the power tending to rupture the piece—was 18·3 tons per square inch of surface. With the chambered gun the initial velocity was 1,585 feet, the shot's energy 34,836 foot-tons, and the pressure on the interior of the chamber fell to 17 tons per square inch. Thus we see that the result of chambering the gun was to add 161 feet to the velocity of the shot and about 6,700 tons to its energy, while reducing the pressure on the interior of the gun by more than 1 ton per square inch. This addition to the striking power of the shot is almost exactly equal to the whole energy of a shot from the English 35-ton gun at 1,200 yards with a charge of 110 lbs. of powder. Again, the highest charge fired from the unchambered gun during the former experiments was 375 lbs. The highest from the chambered gun with English powder was 463 lbs. The results in each case were:

| | Velocity. Feet. | Energy. Foot-tons. | Pressure. Tons. |
|---|---|---|---|
| Unchambered gun.. | 1,542 | 33,000 | 21·4 |
| Chambered gun.... | 1,627 | 36,710 | 20·8 |

No armor, whether intended to guard ship or fort, has ever been constructed capable of resisting the shot delivered from the chambered 100-ton gun with the charge given above. The energy of the shot is nearly four and a half times that of the 35-ton gun at its muzzle.

We now come to the second question—that of the English and Italian powders. And here the result is again extraordinary. There is no necessity to jump to a conclusion as to the superiority of the Italian powder for guns of very great caliber. It may be found hereafter to have defects not yet observed, but until such defects are discovered it may be well to study its advantages. All other things being equal, the best powder will be that which imparts the highest energy to the shot with the least strain on the gun. Taking this maxim as our guide, we will compare certain rounds fired during the experiments this year with different charges. In each case the mean pressure per square inch on the interior of the chamber is given:

| | Energy. Foot-tons. | Mean Pressure. Tons. |
|---|---|---|
| P2 powder..... | 29,678 | 17·1 |
| Fossano powder..... | 30,321 | 19·0 |
| P2 powder..... | 33,807 | 17·5 |
| Fossano powder..... | 34,508 | 14·2 |
| P2 powder..... | 36,710 | 20·8 |
| Fossano powder..... | 38,313 | 17·4 |

Taking the average of these rounds we find that the Fossano powder gave about 1,000 foot-tons more energy than the English, with a reduction of 4 tons in the pressure on the interior of the gun. On the other hand, it must be remarked that the quantity of Fossano powder used was considerably greater than that of the English powder. The average charge of the Italian powder for the three rounds quoted was 492·2 lbs.; that of the English powder only 433·4 lbs. But the amount of powder consumed in each round matters little compared with the extended life of the gun; nor is it this particular size of piece only which is affected by the less destructive powder. The fact that high velocities can be obtained without undue pressure on the interior of the gun renders a further development in the size of great ordnance not only possible, but easy. It seems certain that, if heavier projectiles are required, there is no reason why shells of 2 tons weight should not be fired with a velocity compared with which that of the wind in the wildest storm is but as the breath of a sleeping infant, for the velocity of the shot in the last round we have quoted was 1,661·5 feet per second, or, in round numbers, 1,100 miles an hour, and its weight not far short of 1 ton.

Compared with such astonishing results as these, the technical question of how best to light the charge appears unimportant. We may, however, mention that the English powder is best ignited in the center, and the Italian powder seems, so far, to suffer nothing in its good effects by being ignited at the end of the charge.

At the time of the first experiments at Spezia, there were some men who, not without reason, asked whether artillery science could not now produce guns which, with less weight of the piece and its projectile, would penetrate the sides of ships; whether, in short, the old triumph of the English rifled over American smooth-bore guns could not be carried a little further, so that the new English weapons might throw the old ones into the shade. This question has at last been answered in the affirmative, for the 6-inch Armstrong gun, now at Shoeburyness, has attained velocities of 2,000 feet per second with 70-lb. projectiles, and 2,070 feet per second with 64-lb. projectiles, the pressure in the chamber in no case exceeding 15 tons per square inch. To estimate the comparative power of this gun for penetrative purposes we must not go to the 64 and 70 pounders of the service, for these would be too far behind. Let us take the gun which has a power nearly equal to that of the new 6-inch gun. The new 6-inch gives its shot a penetrative power which is best known to artillerists as that of 110 foot-tons per inch of the shot's circumference, and when we come to consult the tables of guns in the service we find that this power is 10 tons greater than that of the 8-inch service gun at its muzzle, and 1 ton less than that of the 9-inch gun at 400 yards from the muzzle. But is this power attained by some crafty misrepresentation, such as making a heavy gun with a small bore? On the contrary, the new 6-inch gun weighs 77 cwt.—that is, less than 4 tons—while the 8-inch gun weighs 9 tons, or more than double, and the 9-inch gun weighs 12 tons, or more than three times the weight of the 6-inch. Of course the partisans of breech-loaders at all risks will exclaim that this gun is a breech-loader, but none will be more ready than the makers to assure them that in this case breech and muzzle loading have nothing whatever to do with the matter. In fact, they are building both breech-loaders and muzzle-loaders with the same power. It is true that one argument against breech-loaders has been much

weakened now that such high velocities have been attained with a trifling shock to the internal mechanism of the gun, and we rejoice to think that the success may lead to the adoption of breech-loading guns for siege trains. This we have always advocated, not because of any intrinsic superiority in the weapon, but because the gunners working it can be more easily protected from the rifle fire of the enemies' sharpshooters. But, so far as the gun itself is concerned, a muzzle-loader made on the same principles would have the same power—that is to say, a gun constructed on the new principles will be at least as powerful for penetration as one of the old pattern double the weight. Thus, if the conditions are that a certain effect is to be produced, the gun need only be of half the weight formerly necessary; or if the conditions—say the strength of a merchant ship's deck—prevent the use of a gun above a certain weight, then the piece supplied may be twice as powerful as was formerly possible. In saying this we are far within the mark, for not only has the 6-inch gun shown itself superior to the 8-inch of more than double its weight, but pieces of higher caliber are now almost completed which will carry out the proportion and even raise it. The new 8-inch guns, weighing about 11 tons, will be much more powerful for penetration than the old 11-inch pieces of 25 tons, and the 35 and 38 tons will be far surpassed by the new 10-inch gun. We are, therefore, in presence of an extraordinary advance suddenly disclosed in the power of artillery. It is entirely an English development, and should we be unhappily called upon to vindicate our title to the command of the sea for trading purposes, it will have an extremely practical effect. English ships thus armed may not only double their artillery power against ironclads, but sometimes gain a power which they had previously no chance of possessing, for vessels may now be well armed which could not until now be armed at all, while those which might have carried weak guns can now bear an armament of powerful pieces. A high initial velocity given to a projectile means more than a heavy blow upon the adversary; it means longer effective range and better shooting at all ranges. For instance, when we say that the range of the new 6-inch, fired with an elevation of 3°, is 2,713 yards, or, with 5°, 3,795 yards, while that of the old 8-inch—double the weight—is only 1,715 and 2,605 yards respectively with the same elevations, it means more than that the shells range about 1,000 yards further. It means that at any range whatever the new gun will be much more likely to strike an adversary because the path of its projectile through the air is less curved, and, therefore, less likely to pass over the mark. We do not set much store by the ranges of 6,000 yards given by the new gun with 10° of elevation, because the use of such long ranges would be only occasional. Yet there are situations in war when accurate shooting at long range is of the highest value, and no pains should be spared to render such long range shooting more reliable by the use of finer sights and telescopes. For harbor defense and river work the new guns will again give increased power and that in a high degree. The little boats carrying a gun each which were sent by the Elswick firm to China some years ago will now step upward in efficiency, for the very smallest of them can now carry guns as powerful as those formerly carried by the largest. It is worthy of passing remark that the Russian guns have, for the most part, a low velocity, and are in all cases far behind those now produced by England. There is nothing of the kind to be bought in America, and we may hope that the utter futility of finding cruisers armed so as to match merchant steamers which can carry light, far-reaching guns, such as can now be given to them, may be another and a potent argument in favor of peace. All such developments as those we have explained—the largest guns for smashing exceptional ironclad defenses, and the lightest guns to produce any given effect—are fortunate acquisitions at a moment when the peace of the world may depend on England's readiness for war.—*London Times.*

## ROCKET FIRING.

A SUGGESTION for the better employment of rockets has been made to the Royal Artillery Institution at Woolwich, by Lieut. E. N. Henriques, Royal Artillery, who proposes a rocket shell to be fired from a rifled gun. He hopes by that means to secure all the moral advantages attributed to the employment of rockets in the field, and to obviate their special defects, which are—difficulty of laying, irregularities in flight, uncertainty of range, height of trajectory, low velocity at long ranges, small momentum after bursting, great weight of each round, and considerable deflections after graze. The proposed rocket shell, when fired from the gun, would be ignited by a fuse in front of the enemy's line, and carry a bursting charge of gun-cotton in its head.

## NEW TORPEDO BOATS.

Two new torpedo boats, in which some special features have been introduced by the builders, Messrs. Yarrow & Co., of Poplar, England, were lately tried by the Admiralty officials. These vessels are each 85 feet long with 11 feet beam, and draw, when fully equipped for service, an average of 3 feet of water. They are strongly constructed of steel, and are fitted with compound surface-condensing engines capable of indicating 420 horse power. The high-pressure steam cylinder of these engines is 12¼ inches in diameter, and the low-pressure 21¼ inches, both having a 12-inch stroke. These boats are at present known by their builders' numbers, one being No. 419 and the other No. 420. The former is propelled by a three-bladed screw, 5 feet 6 inches diameter and 5 feet pitch; and the latter by a two-bladed screw of similar proportions. Messrs. Yarrow adopt supplementary engines for driving the air-pump, circulating pump and feed pumps; they consider this plan preferable to that of working these pumps direct off the main engine, as is sometimes done. One advantage in having separate pumping engines is that, whether the vessel is in motion or stationary, a powerful means is available for pumping her out, should the necessity arise. It is estimated by her builders that if the air-pump and circulating pump were both utilized for this purpose the water could be pumped out as fast as it could enter either of these vessels through one hundred holes made in the skin by Martini-Henry rifle bullets. If this is the case, these craft may be deemed safe from sinking so long as their machinery is working efficiently. The boiler is of the locomotive type, is placed in the forward part of each vessel, and has a closed stoke-hole. In connection with the boiler a very important improvement has been introduced by Messrs. Yarrow. This consists in a means of rendering the closed stoke-hole safe for the men in the event of the collapse of a boiler tube—a contingency which cannot be absolutely guarded against. The arrangement was explained to us, but, although patented, we are asked not to publish the details. From what we have seen the plan appears very simple, while its efficiency was proved beyond all question upon a previous trial of one of these boats. This was No. 419, which was tried on the 24th May last, under the supervision of the Admiralty officials. Upon that occasion an accidental rupture of one of the boiler tubes occurred nearly at the close of the runs over the measured mile, which so far had been very successful. When the boiler tube gave way the steam rushed out of the foremost hatchway from the compartment in which the smoke-box end of the boiler is situated, and soon after from the two funnels. The men in the stoke-hole, however, being shut off from the boiler, were uninjured, and remained at their post several minutes after the first outburst of steam. The accident, although an untoward event, was considered by the Admiralty officials as affording a highly satisfactory proof of the efficiency of Mr. Yarrow's invention. The engines are placed amidships, and each vessel has spacious cabin accommodation aft, as it is intended that they may be used either as dispatch or torpedo boats. For the latter purpose the cabin framings above deck are removed and replaced by steel plating. These vessels are, in fact, now fitted one for one purpose and one for the other. They are steered from the cabin, there being a lookout for the steersman just above deck-level. The deck is clear of all obstructions, the two funnels being placed one on either side. They are fitted with balanced rudders, and steer well, answering their helms very quickly. These vessels would probably have now been on their way to the Neva but for the Government proclamation which prohibited torpedo boats leaving this country, and which led to their purchase by the English Government.

The above trials were conducted under the supervision of Mr. Neil M'Dougall, on behalf of the Admiralty, the runs being made over the measured mile—or, rather, two miles—at Long Reach. No 420 was first tried, and made the down run over the two-mile course in 5 minutes 19 seconds, which is equal to a speed of 22·59 knots per hour. In other terms, this vessel attained the remarkable speed of 26 miles an hour. She had 6 tons of ballast on board, and her draught forward was 2 feet eight and a half inches, and aft 2 feet 7 inches. Her mean revolutions were 460 per minute; maximum, 475; steam pressure, 120 lbs.; vacuum, 23 to 25 inches, and blast 4 inches. The tide had just turned and was running out, being, therefore, with the vessel on the run down. On the run up it was, of course, against her. This run was made in 6 minutes 47 seconds, or equal to a speed of 17·69 knots per hour. The mean of the two runs was 20·14 knots, or 23·2 miles per hour. On the up run the mean revolutions were 460 per minute, the steam-pressure 120 lbs., the vacuum 24 inches, and the blast 4 inches. The vessel was under way just an hour, during which time she burned 10 cwt. of coal, a portion of which was used in getting up steam. No. 419 was then tried. She was run light, without any ballast, her draught forward being 2 feet 5 inches, and aft 2 feet 4 inches. The first run was made up the river, and, consequently, against the tide. The two miles were run in 6 minutes 38 seconds, giving a speed of 18·09 knots per hour. The mean revolutions were 459, the steam-pressure 110 lbs., the vacuum 22 inches, and the blast 4 and a half inches. The second run was made down the river, and, consequently, with the tide. Here the two miles were accomplished in 5 minutes 1 second, giving a speed of 23·92 knots, or 27·56 miles per hour. The mean of the two runs was a speed of 21 knots, or 24·2 miles per hour. On the last run the mean revolutions were 459, the steam-pressure 110 lbs., the vacuum 22 inches, and the blast 4 and three-quarter inches. This boat was then put through the circle, and in this trial she described a circle half a knot in circumference, or rather more than 1,000 feet in diameter, in 2 minutes 31 seconds. There were no heated bearings or any other drawbacks during these trials, which were highly satisfactory in every respect.

## COMPRESSED AIR IN MINES.

By M. G. JOHNSON, of the Kingswood Collieries, Bristol.

AMONG the collieries visited by Mr. Cossham were included Ryhope and Shireoaks, and at each of these collieries compressed air is being used with excellent results. The same may be said of all the places I visited in South Wales—in one colliery no less than 40 horses had been dispensed with through the application of this power. Great credit is due to Sir George Elliot for the persistent efforts he has made and the money he has spent in order to bring as near perfection as possible the methods for obtaining this power. In the Powell's Duffryn Collieries, in South Wales, the proprietors are so convinced of the benefits to be derived from its use that they are dispensing altogether with animal power, and substituting air engines for their underground haulage; and the testimony of these collieries (Mr. Wilkinson, manager, and Mr. Snape, engineer) was to the effect that after ten years' experience in the use of compressed air they are fully convinced that there is no power equal to it for winning coal back to the shaft where steam cannot be conveniently employed, and where the coal lies to the dip. At New Tredegar Collieries, belonging to the same firm, this motor is, I am told, extensively employed. They have no coal works but what lie below 1,500 yards to the dip, and from that distance down to 2,000 yards, the lowest point reached at that time (two years ago), they were hauling 800 tons per day.

When the Mont Cenis Tunnel had to be driven, the engineers, Messrs. Sommellier and Grattoni, at once recognized this power, and availed themselves of it, and but for this I have no doubt the completion of that grand engineering feat would have been retarded for at least five years. It not only served as the power for driving their rock drills, but it cleared away the smoke after blasting almost immediately, and enabled the men to resume work at the face of the heading without any unnecessary loss of time, and to get the debris at once cleared away. Every miner knows that the hanging of the smoke in the ordinary method very often keeps him away from the place of his work quite one-fifth of his time, so that this power not only permits much more work to be done, but admits of its being done in a healthy atmosphere instead of in a vitiated one. At Mont Cenis Tunnel, too, they got this power very cheaply at merely the cost of the machinery; a mountain stream running down near the mouth of the tunnel was utilized, and supplied the power for compressing the air. M. Derilley has published an elaborate and most valuable report on the work done at this tunnel, and much information is given therein respecting their method of compressing the air. Mr. Taylor, of Ryhope Colliery, in a paper read before the North of England Institute of Engineers some few years ago, enumerates some of the advantages resulting from the use of this power:—1. It is obviously of great importance to have a large power which can be applied to any purpose, and at any moment, to any part of the mine. 2. Possessing this power is a mere question of detail to use means for working the coal and bringing it to the point from which it is to be led by the air engine, thus dispensing in a great measure with manual labor, both as regards hewing and putting the coals. 3. Compressed air at 40 lbs. pressure has been successfully tried at Ryhope for airing a stone drift, and he sums up the results as follows: 1. Economy as regards its application to any part of the mine. 2. Additional safety to the mine, inasmuch as there is more direct communication with and control over all parts. 3. Having a power so easy of application to any part of the mine, its use for all purposes where labor is concerned must necessarily follow.

M. Trasenter, Professor of Mining at the University of Liége, considers that great advantages must ensue from the use of this power for driving engines at high speed in the galleries or working places underground, through the freedom from heating and condensation, slight friction in the pipes, and the ventilation in the works; but while enumerating its advantages we must not fail to look fairly in the face what are considered to be the drawbacks to its general adoption. Mr. Trasenter says compressed air necessitates costly works, and if used without expansion it leads to a great loss of power owing to the necessity for conducting the air at the required pressure. In calculating the ratio of the energy expended in compressing the air to the useful work theoretically given out, Mr. Trasenter has laid down a simple and interesting formula. The work given out soon reaches a limit which cannot be exceeded, whatever may be the pressure of the air or the energy expended. The maximum of work given out (increasing the compression indefinitely, and without taking into consideration the elevation of temperature due to this compression) cannot exceed the energy given out by the volume of air caused by the piston of the blowing cylinder working with an effective pressure of one atmosphere, and he demonstrates the law, and goes on to say that the power which a cubic meter of air, compressed to a million atmospheres, is capable of yielding, without taking the rise of temperature into consideration, can never become double that which the same quantity of air, compressed to two atmospheres, is capable of yielding. Air compressed to four atmospheres will give out a power proportional to 1—¼, or ¾, whereas to obtain a power equal to 1 a compression infinitely great is necessary. He gives a formula which expresses the ratio of the work done to the power expended This power is not a new discovery; Hero, of Alexandria, was in some measure acquainted with it, as well as with the knowledge of steam as a motive power. Hero's tutor, Ctesibuis, is said to have discovered that air was compressible, and the pupil is credited with having written a book on pneumatics, showing that when air was compressed it decreased in volume, and expanded itself again when the pressure was removed. Experiments proving its "ponderability" were made in the 17th century by Galileo and Torricelli; about the same time, too, Guericke invented the air pump. Its chemical properties, however, did not engage much attention until another century had elapsed, when Black, Priestley, Lavoisier, and others took up the subject, and great discoveries resulted from their labors. Papin, about the beginning of last century, had an idea of working an engine with air, generated by a water-wheel and compressing pump at a distance, but it was not brought into practice; and just 100 years before the Mont Cenis Tunnel was commenced one Isaac Wilkinson obtained a patent for a machine for compressing air very similar to the one employed at those works. It is generally known that when air or other elastic fluid is compressed, there is generated an amount of heat which is the exact equivalent of the force employed in the compression.

It may not be out of place here to give an extract from Professor Tyndall's valuable work, "Heat a Mode of Motion." He says:

"Whenever friction is overcome (by compression or otherwise) heat is produced, and the heat produced is the exact measure of the force expended in overcoming the friction. The heat is simply the primitive force in another form, and if we wish to avoid this conversion we must abolish the friction. We put oil upon the surface of a bone, we grease a saw, and are careful to lubricate the axles of our railway carriages. What is the real meaning of these acts? Let us obtain general motions first, and aim at strict accuracy afterward. It is the object of a railway engine driver to urge his train from one place to another; he wishes to employ the force of his steam; it is not his object or interest to allow any portion of that force to be converted into another form of force which would not promote the attainment of his object; he does not want his axles heated, and hence he avoids as much as possible expending his power in heating them—in fact, he obtained his power from heat, and it is not his object to reconvert by friction the force thus obtained into its primitive form. For every degree of temperature generated in his axles a definite amount would be withdrawn from the urging force of his engine. There is no absolute loss. Could we gather up all the heat generated by the friction, and could we apply it mechanically, we should by it be able to impart to the train the precise amount of speed which it had lost by the friction. Thus every one of those railway porters whom you see moving about with his can of yellow grease, and opening the little boxes which surround the carriage axles, is, without knowing it, illustrating a principle which forms the solder of nature; he is unconsciously affirming both the convertibility and the indestructibility of force. All the force of our locomotives is derived from heat. When a station is approached—say at the rate of 30 miles an hour—a brake is applied, and smoke and sparks issue from the wheels on which it presses. The train is brought to rest. How? Simply by converting the entire moving force which it possessed at the moment the brake was applied into heat."

The heat in actual practice is to a very considerable extent lost by radiation from the receiver and pipes in use; and further, when this compressed air has fallen to the temperature it possessed prior to its being compressed, it has lost in cooling an exact equivalent of the power expended in compressing it. Where, then, is the power to perform work? This remains in the stored-up air in the reservoir, where it is held under considerable pressure, and when allowed to expand in a working cylinder its temperature then falls below that of the atmosphere, and thus develops the work demanded from it. In accomplishing this, however, there is a loss of about 30 to 40 per cent. in consequence of the temperature of expansion not being depressed in an equal proportion to the increase obtained during its compression; and hence when the air has done its work in the cylinder, and issues forth from the exhaust passage, it is exceedingly cold, being about 28½° Fahr., or 3½° below freezing point. This intense cold formed for a considerable time very serious objections in its practical use as an engine

motor, through the formation of ice at the exhaust. Various methods have been resorted to to remedy this defect, but this is effectually accomplished by casting the cylinder so as to have the exhaust openings connected with the exhaust port vertically, and open across the cylinder, so as to discharge the air downward as well as upward, and admit of a bar being passed through, if necessary, to chip off the ice. It would appear from the foregoing that the higher the air was pressed the greater would be the loss in the economic result; but in this there is a great difference of opinion, one party going in for slow speed and low pressures, not above three atmospheres, and another for high speed and high pressures. It is a very common expression, and true, that circumstances alter cases, and so, in my opinion, it is in this, the "battle of pressures."

I do not wish to be dogmatic in this matter. Douglas Jerrold once said that dogmatism was grown-up puppyism; and I know, too, there is a proverb which says that a certain class of people, the opposite to wise, rush in where angels fear to tread. Where the work, however, to be accomplished is of a temporary nature, such as tunneling, deep well sinking or boring, high speeds and high pressures may be adopted with advantage, as they admit of smaller machines being used to do the desired amount of work; but where the power is required for the running of a colliery to extend over 20, 30, or 40 years, and the air to be carried to long distances for hauling, pumping, rock drilling, and coal cutting purposes, then I say put down a good compressing plant, with moderate speed, ordinary pressure of (say) three atmospheres, and plenty of margin. This is my view of the matter, and must be taken for what it is worth. An athlete, in running a hundred yard race, starts away at a very different speed to what the one does who is in for a mile race; it is the old fable of the hare and the tortoise.

Looking at the matter in this light, the Kingswood Coal and Iron Company ordered a pair of air compressors from Messrs. J. Fowler & Co., of Leeds, of the following dimensions: The steam cylinders are 36 in. diameter, the air cylinders being 40 in. diameter, with a 5-ft. stroke. The air cylinders are immediately behind the steam cylinders, and fixed to the same bed plate; the piston is continuous, but so arranged that no part of the rod that works in the steam cylinder shall enter the air cylinders or even the stuffing box. The air cylinders are cast with square ends and flanges to attach flat plates vertically at the sides, thus forming a tank or receptacle for a complete jacketing of cold water, the object of the cold water being to keep the temperature of the air as low as possible during compression, the top left open to allow of evaporation and radiation. The supply of cold water is kept up by a pipe at the under side, getting its supply from a reservoir at a higher level than the tops of the cylinders, and the heated water is passed off at an overflow pipe at the top, the inlet and outlet being regulated by taps. The air is forced into a receiver, which is nothing more than an ordinary egg-end boiler, 25 ft. long and 5 ft. in diameter, fitted with stop valve and safety valves, the latter weighted to 45 lbs. per square inch. Steam is supplied at 40 lbs. per square inch, and the pressure of air stands at 45 lbs. per square inch; the steam is cut off at 3/4 in. of the stroke; the fly wheel is 21 ft. diameter, and weighs about 24 tons. From the receiver toward the shaft an old boiler tube, 28 ft. long, 2 ft. 10 in. diameter, is utilized, and from this cast iron pipes 8 in. diameter are carried down the shaft for 225 yards; at this depth, and in an opening in the side of the shaft, a pumping engine is fixed and driven by the compressed air. This engine consists of a pair of air cylinders, 10 in. diameter and 2 ft. stroke, which drives a pair of rams 6 in. diameter, geared 5 to 1, with air pressure at 40 lbs., and delivers 160 gallons of water per minute 700 ft. high. The out and out dimensions of this pump are 15 ft. long, 7 ft. 6 in. wide, and 6 ft. 3 in. high. These compressors and pump, made by Messrs. Fowler & Co., of Leeds, have given the most unqualified satisfaction. The air pressure at this point, more than 250 yards from compressors, stands at 2 lbs. higher than it does in the receiver at surface, and my experience is that the pressure increases about 1 lb. for every 100 yards of depth. We have tested this by changing gauges; the same has also been observed by Mr. Snape, engineer, and Sir George Elliot, who has had more than 11 years' experience with compressing machinery. I do not intend here to account for this, but merely state the fact. We have 7 in. pipes continued for the remaining 270 yards down to the bottom of the shaft, and for the present have a dead flange screwed on the end of the pipes, but we have already two pairs of hauling engines on order, and hope to have them at work in a few months—one pair for level haulage, the other for dip haulage. I anticipate, therefore, when we come to put the pressure gauge on at the pit bottom, that the pressure there will register about 5 lbs. higher than at the surface receiver.

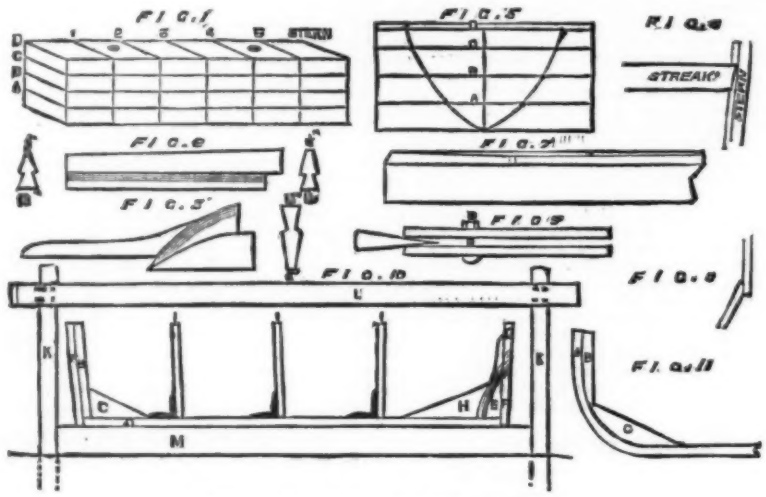
## HOW TO GET BOAT LINES.

By R. COOPER, Parry Sound, Canada.

I WILL describe the method I adopted in building a clincher-built boat, 17 ft. long, 4 ft. beam, 2 ft. deep at head and stern, and 1 ft. 1½ in. at midship. Take four pieces of pine, 17 in. long, 9 in. wide, and ½ in. thick, dressed up quite true, glue them together, and put two screws through them to hold them together; divide the length into six equal parts, and draw a line square across the top at each division. Then with a square draw a line down the side from the end of each line on the top, take out the screws, and cut the model of half the boat on the side not marked. Then place it in water to soften the glue, and take it to pieces and dry it, then draw a line across the top of each piece from the lines on the sides, number the divisions, beginning at the stem,

1, 2, 3, 4, 5, and stern,
1⅜ 1⅞ 2 1⅞ 1⅝ 1½ in.,

as Fig. 1. My model was the respective breadths given under each number of divisions. The joints where the pieces come together and the top may be marked A, B, C, D. The model is made upon the scale of ¾ in. to the foot. The first thing to make is the keel. This may be made in different ways; it may be made of a board any breadth required, and tapered off from midship to both ends, in which case the edges are worked up so as to nail the strakes to. The keel proper is nailed on this board when the boat is finished, or it may be made out of a piece of wood placed edgeways, in which case a groove or rabbet is worked out on each side to nail the first strake to. The stem is made from a piece of wood, 3 in. by 2 in. at top, and 4 in. by 1½ in. at bottom (Fig. 2), with a rabbet on each side for the ends of the strakes to fit into, and a piece taken out at bottom to fit on keel. The stern-post is made from a piece of wood, 2 in. thick and 5 in. wide at bottom, and 2 in. wide at top (Fig. 3). A rabbet is taken out at each side for the ends of strakes to fit into from the bottom to the part where the stern-piece fits on to the stern-post. The stern-piece is cut out and nailed to the stern-post, the shape being taken from the model. A piece is taken out of the bottom of stern-post, and stem and stern are nailed to keel. A 1 in. or 1⅛ in. board is firmly fixed edgeways on the ground, and the keel firmly fixed on the top edge with screws, the stem and stern being firmly fixed in a perpendicular position. Divide the keel into as many parts as you have in the length of the model, and make a mark square across. To make the shapes or templates to give shape to the boat take a piece of board for each template, and lay off three parallel lines, the first 6 in. from the bottom edge of the board, and the others 6 in. apart; mark the lines A, B, C. Draw a line in the center of the board perpendicular to the bottom edge. Take the model apart, and measure with a pair of fine compasses and scale the width of the model at line No. 1, at joint marked A; transfer this distance in inches to line A on the board on each side of perpendicular line, and make a mark; then measure the width of second piece, marked B, and transfer this to line B, and mark as before; then measure the top side of third piece, marked C, and transfer it to line C, and mark. Repeat this with each of the other sections and stern, then put the model together and measure the flat side opposite each division and set it off in inches on the perpendicular line of each template, and mark; draw a line parallel through this mark and mark it D; set off on this line the widths at 1, 2, 3, 4, 5, and stern, and mark these places on the line; draw a curved line through the marks of the lines on each template, and cut by these lines; a piece of whalebone, a thin lath, or a piece of stout crinoline wire is convenient to draw the curves with. The templates are numbered to correspond with the divisions on the model, and are fixed with an iron angle or otherwise to the keel on the line corresponding with their numbers, and are firmly fixed with stays. It is very important that the center of stem, stern, and center line of the templates should be in a line; it is obvious that the model may be divided into any number of divisions that is convenient, or if a carvel-built boat is required a division may be made for each rib. If greater accuracy is required the model may be made with 6¼ in. pieces instead of 3½ in. pieces for the three lower pieces, and the lines 3 in. apart on the templates. The midship section or template may be divided into a number of unequal parts on the outer edge, according to the number of strakes. Where the section is flat they may be wider, where round narrower. The stem and stern may be similarly divided. Now take a lath and fix it on the marks at stem, stern and midship, and mark the edges of the other sections. This will give you an idea of the width and shape of the strakes. To get the shape of the strakes




HOW TO GET BOAT LINES.

get a thin board about 3-16 in. thick, 6 in. wide, and 12 or 14 ft. long. This is called the curve board. Also a piece of wood 1 in. square and 12 or 14 ft. long. Chalk the curve board and rub it down with a cloth; lay it on the boat where you require the strake; being light it will easily bend and fit. Fasten it with clamps, then mark with a pencil along the edge of the keel or strake, as the case may be, inside. Take off the curve board, lay it on the board from which you intend to cut the strake, pencil mark on top; provide a number of bradawls, and put them through the center of the 1 in. lath, about 15 in. apart. Lay the lath on the curve board close to the low side of the pencil mark, and stick the bradawl through the curve board into the wood to form the strake, bend the lath to the line, and stick the other bradawls through until it is so fixed the full length, then pull out the bradawls from the wood and curve board, but leave them in the lath, place the curve board on one side, and stick the bradawls into the holes made in the wood; then, with a pencil, mark the opposite side of the lath to the line on the curve-board. This will give you the shape of the strake with one inch lap for nailing. Cut the other edge of strake according to judgment, cut out another piece the same size and shape for opposite side, and dress up. It is easier to put the strakes on in two pieces than all in one piece; if done in this way the piece at stern must be put on first, say two-thirds the length of the boat. The end of the strake must be fitted into the recess formed in the sternpost, then cut the other end square off with a fine saw, lay on a try square and mark with a pencil the width of the blade on the outside of the board, with a broad firmer chisel cut off from this mark to an edge on the opposite side of the wood, thus forming a wedge-shaped splice. Make a pencil mark 1 in. from the top edge on the outside, and another 1 in. from the bottom edge inside; with a spokeshave dress off the top outside edge at stern from the line to the opposite edge, coming off to nothing about 18 in. from the end of the board (Fig. 5). The next strake will have to be dressed off in a similar way at the bottom to fit on this. These two pieces may now be steeped in water, steamed, or put on as they are—it is best to steam them; if not convenient, steep them in water as long as you can, then fix and nail them in their places; get the forward part of the strake in the same way, making them a little longer than required; fit the front end to the stern. In fitting the end of the strake bevel to fit the stern rabbet make the bevel greater than apparently necessary, as it is reduced in bending (Fig. 6). Fix the strake in its place with clamps, and make a mark across where the other piece of the strake joins it; take off the strake and lay the blade of the square close up to the line, and draw a line on the other side of the blade. Cut off by this line, and with a broad chisel cut off the wood from this line to the opposite edge of the board. If carefully done this will make a good splice; it may be nailed with 1 in. nails. Make lines 1 in. from the edges, as in the first place, and dress off top edge same as for stern. In making the next strake let the splice be one-third from the stern, so that the splices cross each other; proceed thus until all the strakes are put on. In the parts where the mould of the boat is nearly straight nothing will be required to be done, but where it is round the outside of the lower strake is to be dressed off (Fig. 7) with a spokeshave, to get the necessary shape, how much or how little may be judged from the edge of the template. Nothing is to be taken off the top strake at bottom edge, but at the ends where the two boards are fixed to stem and stern. A useful kind of cramp for boat building may be made of two pieces of hard wood, 1 in. thick, 2 in. wide, and 14 in. long; a ½ in. hole is bored through 6 in. from the end, and a ½ in. bolt put through long enough to give a little play, 3½ in. or 4 in. long, and a wedge to drive in between them to tighten them up (Fig. 9). Having got all the strakes on, take out the templates, and fit in the ribs, which may be made of oak, ¾ in. wide and ½ in. thick. These may be steamed and bent into their places and nailed fast, putting the nail-heads outside. Take two strips of wood, 1½ in. or 2 in. wide and ½ in. thick, nail one outside the top strake along the gunwale, the other outside upon the top of the ribs. On each side of the boat a solid block must be inserted where the rowlocks come, and an iron plate put on with a hole in it for the rowlock to drop into. This hole may be 12 in. abaft the after edge of the thwart. Next, the rising, which is a piece of wood 1½ in. wide and ¾ in. thick, nearly the length of the boat, is fixed inside and following the gunwale of the boat, and about 5 in. below it for the thwarts to be fixed to. It is nailed to each rib, and the thwarts are laid upon this, and are long enough to butt against the strake on each side. A knee is put in at each end of the thwart, butting against the strake and coming 6 in. on the thwart. It is now ready for the ceiling or floor, which consists of one board down the middle, 6 or 8 in. wide in the middle, and tapered off at each end to fit the boat. To make it lie level and firm cleats are nailed on the underside, across it, and a board, sometimes two boards, nailed on each side of it. They are 3 or 4 in. wide, and ¾ in. thick. The center one is left loose. I have used cut clout nails 1, 1½ and 1½ in. long, heads outside, and clinched inside, 2 to 2½ in. apart. If found brittle they may be softened by putting in the fire and left till the fire goes out. A convenient steaming box may be made of four boards, 1½ in. thick; two may be 12 in. wide, and the others 4 in. wide. The narrow ones may be firmly nailed between the others, forming a box, any length required, 4 in. by 9 in. One end may be nailed in, the other fit loose, or, when steaming, a tuft of hay may be put in to close the end. Get a kettle and fit a wooden lid to it tight. Make a hole in the center, and fit a wood pipe in it. The other end of pipe must be fitted to the underside of box. Bore a hole in the lid and fit a plug, place the boiler under the box a little way from the ground, put in water and insert the plug. Make a fire under, and when steam is up put in the article and close the end until steamed sufficiently.

The stem is sometimes made of two pieces. That part to which the ends of the strakes are nailed is called the apron, and is sometimes made separately, and nailed to the stem proper. There are two blocks fitted into the angle of the stem and keel, and stern and keel. These are called respectively the stem dead wood and the stern dead wood (Fig. 10). When the apron is made separately the dead wood is fitted up to the stem, and the bottom of the apron fitted upon that; but if the stem and apron are made from one piece the dead wood is fitted to the apron. It will be easier for an amateur to fit the dead wood in after one or two strakes are on. The stem can be made curved, if required, instead of straight, in which case it is better to make the apron separately, as shown in Fig. 11.

I have lately seen a very light canoe, 14½ ft. long, 30 in. beam, 12 in. deep, stem and stern, carvel built, with a very flat bottom, no keel except about 2½ ft. or 3 ft. from stem and stern, the sides cambered in at midships. The ribs were 6 in. apart, the strakes were ¾ in. or ½ in. thick, as near as I could tell, and were put on in three strakes on each side, nailed to the ribs where the strakes joined. A piece of wood, 1 in. wide and ⅜ in. thick, was fitted in between the ribs along the joint, and nailed along the edge of each strake. The stem and stern were made like a wedge, and the strakes were carried beyond the edge and nailed together. A narrow iron strut was carried along the joint, and 2 ft. under the keel a good block was put in at bow and stern about 2 ft. long, and four stays fixed across from gunwale to gunwale. A 1 in. half round bead was fitted round the gunwale.

References to letters in Figs. 10 and 11. A, the stem; B, the apron; C, bow dead wood; D, keel; E and F, sternpost; G, sternpiece; H, stern dead wood; I, templates; K K, posts; L, scantling to stay to; M, the stocks. The dark lines in Fig. 10 are angle-irons to fix template to keel.—*English Mechanic.*

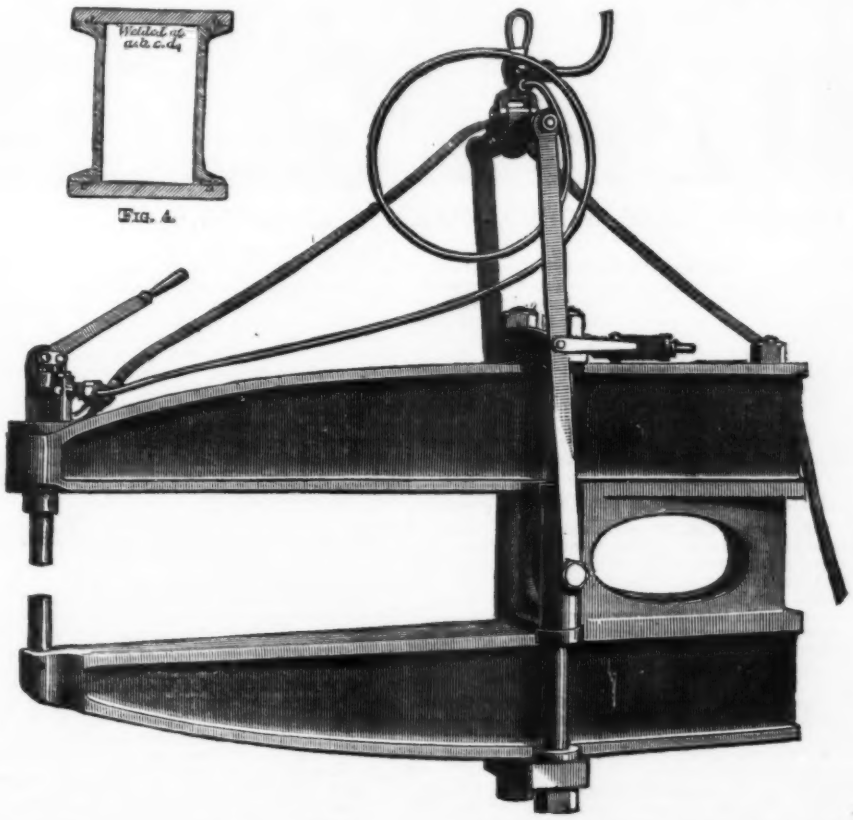
## HYDRAULIC RIVETING MACHINES AT THE PARIS EXHIBITION.

THE whole of the machines exhibited by Mr. Tweddell are in working order, and if fires were allowed in the Machinery Hall they would be at work closing rivets, etc. In default of the means of heating iron rivets, model rivets in lead only can be used, and the perfectly noiseless manner in which these rivets are closed is in startling contrast to the deafening noise caused by a small neighboring riveting machine worked by compressed air in the same gallery of the Exhibition. We must also say that great credit is due to Messrs. Fielding & Platt, of Gloucester, the makers of Mr. Tweddell's riveting machines, who must have gone to a very considerable expense in sending over an exhibit which is so creditable in point of extent and workmanship. The necessary mains, etc., are laid underground to work the various machines at a pressure of 1,500 lbs. Adjoining the space occupied by the hydraulic riveting plant is that of the Hydraulic Engineering Company, Limited, of Chester, who exhibit some of Mr. Tweddell's hydraulic punching and shearing machines, hydraulic bending machines, etc., in addition to the most complete system of hydraulic capstans, cranes, etc., all in actual work. We hope shortly to describe the chief features of this exhibit, and meanwhile we may remark that this is the first time that hydraulic machinery has been properly exhibited in any similar manner.

We have on former occasions pointed out the facilities which the hydraulic system of riveting offers for the production of machines which are not merely nominally portable, but are really so, and the exhibits at Paris which form the subject of the present notice well illustrate the manner in which Mr. Tweddell has turned the capabilities of the system to account. Keeping strictly to the same system, the portable machines constructed on Mr. Tweddell's plans are made in every variety of form, according to the work to be done. The machines exhibited at Paris give a good idea of the advantages to be obtained by the use of these portable machines, and also illustrate the different ways of suspending them. Thus there is first a portable machine, suspended from a jib crane attached to a gantry, then one of the next larger size, combined with a cast-iron standard, and, lastly, one which we now illustrate (see Fig. 1, annexed). With the exception of the modes of suspension, these machines are all of one type, and consist of two levers or arms abutting at one extremity, and carrying at the other two cupped dies, used to form the head of the rivet. Upon one of these levers rests the bottom of a hydraulic cylinder, in which works a plunger, carrying a crosshead furnished with tension bars, which, after passing through guides on each side of the cylinder, are fastened to the other lever, as shown in our engraving. The fulcrum is not situated at the center of the length of the levers, but at a point distant about one-third of that length from one end, and the fittings at the ends of the levers are arranged in such a manner that when desired the cupping dies can be exchanged for abutment dies, and riveting can thus be done at either end of the

FIG. 1.—PORTABLE HYDRAULIC RIVETER.

FIG. 2.—RIVETER FOR FIRE-HOLE RINGS.



FIGS. 3 AND 4.—TWEDDELL'S GIRDER RIVETING MACHINE.

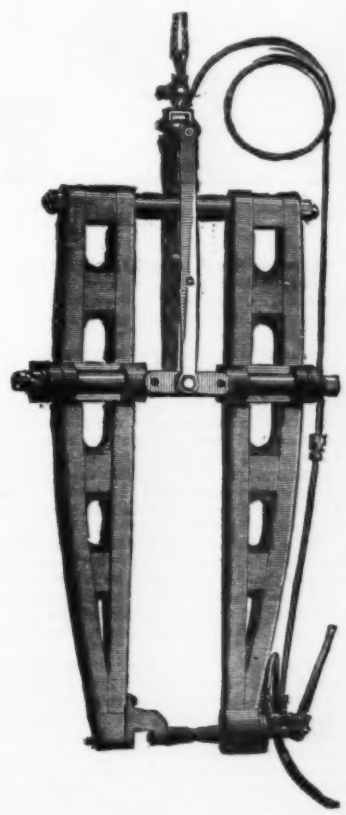


FIG. 5.—HYDRAULIC RIVETER.

levers, the size of rivet which the machine can close depending upon which end is used. Thus, supposing the machine can close rivets of a certain size when the cupping dies are on the short ends of the levers, the size of rivets which can be done when the dies are on the larger arms will be smaller in proportion to the increase of gap.

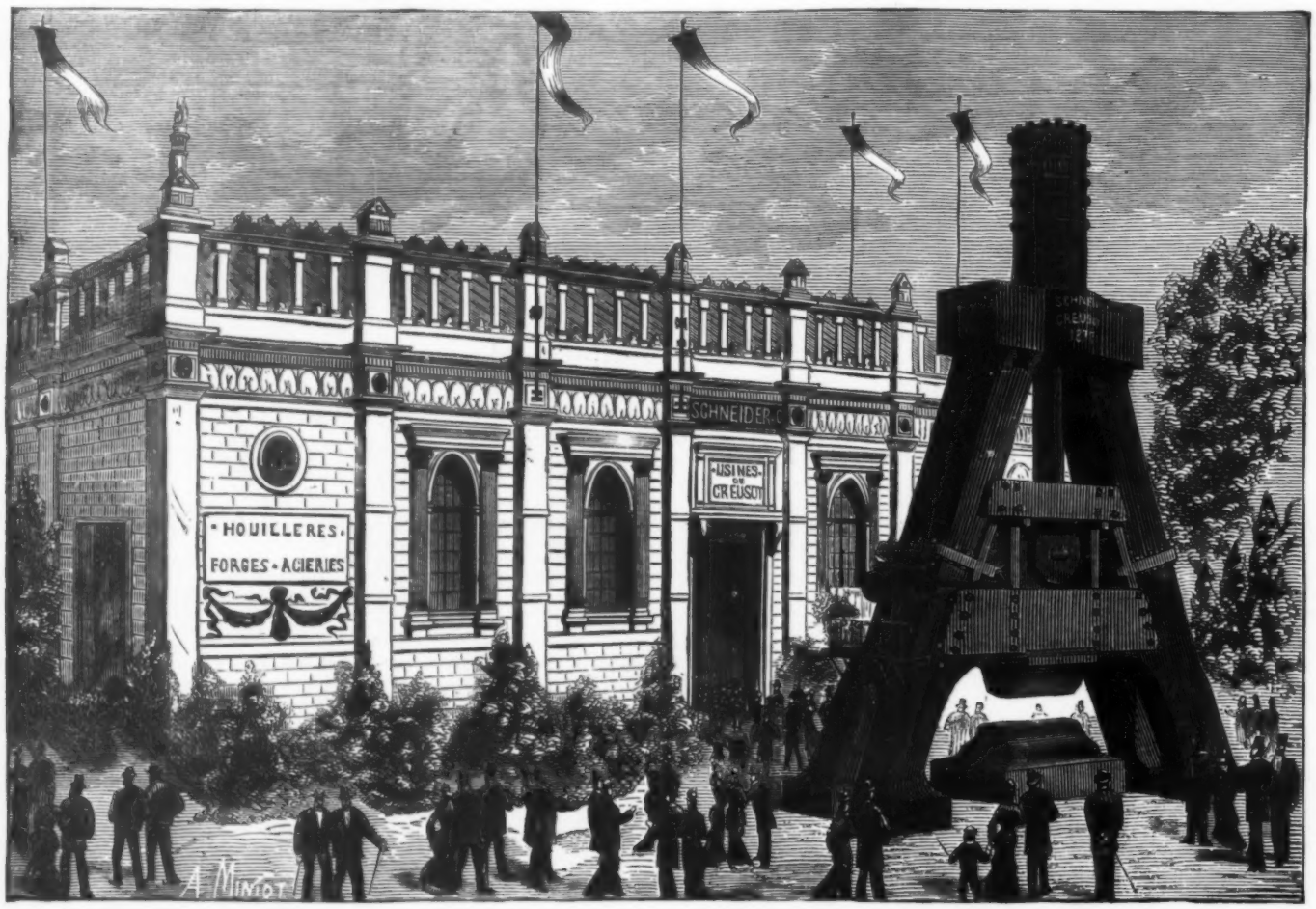
The smallest of the portable machines exhibited at Paris weighs little over 400 lbs., and can close rivets up to $\frac{7}{8}$ in. diameter. All these machines are suspended in such a manner that they can work in either a horizontal or vertical position indiscriminately; and, moreover, a swivel joint placed at the point of suspension allows the machine to describe a complete circle in a horizontal plane. By means of the quadrant suspending gear, shown in our illustration (Fig. 1), page 2225, even greater facility of movement is obtained, as this arrangement allows the machine to move in three directions simultaneously, without having to undo a single joint. The position of the machine can also be changed for each rivet, which is of great importance in irregular work. The success of these very novel machines has led to sundry modifications to meet special cases, some of which we propose now to describe. Many of our readers, by the way, will remember a very good display of this type of Mr. Tweddell's machine tools at the Philadelphia Exhibition, made by Messrs. William Sellers & Co., who are the manufacturers of these machines in the United States.

The portable hydraulic riveter for fire-hole rings, of which we also give an engraving (see Fig. 2), differs considerably from the original type of portable riveter designed by Mr. Tweddell. The first machine of the class illustrated was designed for Mr. Webb for the special purpose of riveting up locomotive fire-hole door rings at Crewe. Mr. Webb was the first to adopt hydraulic riveting for his locomotive foundation rings (see *Engineering*, page 115, vol. xxi.), and

diagonals of lattice girders, etc. While this compact little machine weighs but 400 lbs., it exerts a force of 33,000 foot-pounds each stroke, or a closing pressure of over 30 tons, and can make twenty to thirty strokes per minute.

Another machine, exhibited at Paris, of which we give an engraving (see Fig. 3), is Mr. Tweddell's patent portable girder riveting machine, constructed by Messrs. Fielding & Platt, engineers, Gloucester. This machine is not only remarkable for the work it is capable of doing, but it is also one of the best specimens of smith's work in the building. As will be seen by the section (Fig. 4), the arms or frame of machine is constructed of a box section, *i.e.*, two vertical channel irons with top and bottom plate members. In ordinary practice these are riveted together by hydraulic pressure, but we presume the makers elected to weld the machine as a *tour de force*. In order to obtain the required taper a gusset was cut out of the channel irons, and the two sides being brought together were welded, and then the top and bottom members welded up. This machine is capable of closing $\frac{3}{4}$ in. to $\frac{7}{8}$ in. rivets, weighing but 17 cwts. complete. Machines of this type have, we understand, been most successfully used in the manufacture of wrought-iron wagon underframes by Messrs. P. & W. Maclellan, of Glasgow. The first of these machines of Mr. Tweddell's was used so far back as 1873, at the Primrose Street Bridge, Great Eastern Extension Railway, Liverpool street, E. C., by Mr. W. H. Panton, the builder of the bridge. The same gentleman some time ago, in conjunction with Mr. Tweddell, designed and used most successfully a very large machine, entirely constructed of wrought iron, on a bridge 8 ft. deep and 300 ft. long, for abroad. Every rivet was put on by this machine and a portable riveter of the type illustrated. There were 15,000 $\frac{7}{8}$-in. rivets in the webs and flanges, and every rivet was closed by hydraulic pressure.

It will be seen that although the machine is shown riveting in a horizontal position, by slackening the nut of the suspending link the machine can assume a vertical position, while by means of a swivel arrangement it can move all round in a horizontal plane without disconnecting any joint. In Fig. 5 another of these machines (also exhibited at Paris), of slightly different design, is shown hanging vertically. These machines can close from 2,000 to 4,000 rivets per day of ten hours, according to the nature of the work. We must, in concluding our notice of this section of his exhibits, congratulate Mr. Tweddell on having makers who put so much skill and finish into their productions.—*Engineering.*




PAVILION OF THE CREUSOT IRON WORKS.—PARIS EXHIBITION.

## THE LARGEST STEAM HAMMER IN THE WORLD.

IT is well known that the enormous steam hammer, weighing 50 tons, in use at the Krupp works, in Essen, has up to the present time remained the most powerful apparatus of the kind ever constructed. But Messrs. Schneider & Co., of Le Creusot, leaving far behind them everything that has hitherto been done in this line, have recently erected at their forges a steam hammer of such proportions that, although a mass of about 75 tons only is at present utilized, this power may be increased and carried up to 80 tons, and even beyond.

This colossal engine is composed of four very distinct parts—the foundation or substructure; the standards and entablature, forming the superstructure; the steam cylinder, with its distributing valves; and finally the active mass, or hammer-head, and its accessories.

The foundation is composed of masonry laid in cement, and resting on a bed of rock at a depth of 35 feet beneath the surface, and of a hammer block of cast-iron resting on madriers of oak wood placed in horizontal layers, the object of this being to weaken, by its elasticity, the vibrations resulting from the blow of the hammer. The space between the masonry and the hammer block is likewise filled in with oak wood arranged in horizontal and vertical layers alternately. The hammer block weighs 730 tons, and is formed of six castings lying one on the other in horizontal courses. Each course is composed of two pieces, excepting the upper one supporting the anvil, which is of a single piece, weighing 120 tons. The entire hammer block, with a total height of 19 feet, a base of 108 square feet, and top of 23 square feet, is formed, then, of eleven pieces, all of which are strongly bound together. As may readily be seen, the hammer block is independent of the standards.

The latter are hollow castings inclined toward each other in the form of the letter A; their bases rest upon and are bolted to a bed-plate fastened to the masonry surrounding the hammer block; at their summit they are united by the entablature which supports the steam cylinder. The standards, each composed of two pieces strongly bolted together, are united by large plates of wrought iron. Their height is 33½ feet, and their weight 250 tons.

The whole structure is extremely solid, as experience has shown since the hammer has been working regularly.

Four gas furnaces and four immense cranes of a power of 100 to 150 tons minister to the requirements of this hammer.

These cranes, constructed of iron plates, belong to the class moving on a single pivot, and have the form of a swan's neck. Each one carries a small steam motor, capable of giving it four different movements.

If we compare the power of the hammer-head of Le Creusot with that of Essen from the standpoint alone of mechanical work, on the hypothesis of the fall of the striking mass and of the greatest possible height each of them can fall, we find that the work of a blow of the Le Creusot hammer is 907,500 pounds, while that of the Essen hammer is only 330,000 pounds, a ratio of nearly three to one.

The height of the hammer from the bed-plate to the top of the steam cylinder is 61 feet; adding to this the height of the hammer block and the thickness of the masonry which supports it, we find that this colossal structure has an entire height of about 98 feet. In spite of this condition, so unfavorable to stability, and in spite of the enormous effect resulting from the blows of a hammer of such weight, the construction is so perfect and so well proportioned that it does not vibrate; and the foundation, cushioned by the oak madriers, transmits to the earth only the feeblest of vibrations—less perceptible even than those caused by hammers of a very inferior power.

## THE PARIS EXHIBITION.—LAMM'S FIRELESS LOCOMOTIVE.

A LOCOMOTIVE on Lamm's system, improved by M. L. Francq, is exhibited at the Paris Exhibition. The system on which this engine is constructed was first suggested for working metropolitan railways many years ago in this journal, and various modifications of the system planned by Mr. Todd, of Leith, and Mr. Lamm, of New Orleans, have been from time to time fully described and illustrated in our pages. It will suffice to say here that power is stored up in highly heated water, and that no fire is carried by the locomotive, the boiler in which is replaced by a simple reservoir, containing water heated under pressure to a point far above the ordinary boiling point. The water gives off steam, which is used in the ordinary way.

A line of railway on which these locomotives are being worked starts from Rueil, a station on the line from Paris to St. Germain, and runs through the villages of Rueil, Mal-Maison, and Bourgival, to Port Marly, where the main station

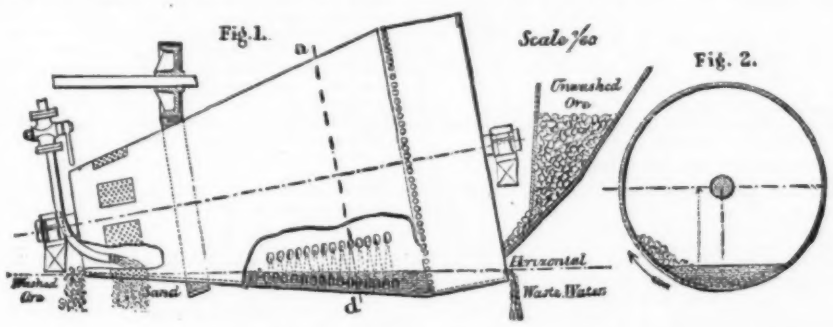
is situated, and again from thence to Marly le Roi, on the hill where the aqueduct for the Versailles fountains commence. The respective distances are: Rueil to Port Marly, 4·66 miles, and Port Marly to Marly le Roi, 1·18 mile. The gradients on the former follow the fall of the Seine, with one or two short pieces of 1 in 35, while on the latter the ruling inclines the whole way are about equally divided into 1 in 18, 1 in 17·85, and 1 in 16·33, the curves throughout both sections being from 95 feet to 100 feet radius. The system of changing the engines is as follows: The reservoir is first filled with 2,000 liters of water, and the engine backed into the boiler house and attached to the steam pipe of the boilers and steam admitted from the latter until the pressure in the reservoir exceeds 15 atmospheres. The theoretical basis of the system is the well known fact that water confined in a space is capable of absorbing and storing up by condensation heat enough to convert one ninth part of its own weight into steam, and the inventors assume that steam so produced and admitted into the cylinders of an engine, exerts a tractive power of 1,800 kilogrammeters per liter of water; therefore, the tractive force of these engines is theoretically 2,000 liters multiplied by 1,800 kilogrammeters = 3,600,000 kilogrammeters. There are two supply boilers, tubular, of about 100 cubic feet each, working alternately, or together, according to the demand on them, with grate areas of about 20 square feet. The amount of fuel consumed is 18 cwt. per diem, and this is sufficient to supply three engines with steam for an aggregate mileage of 326 kilos. or 202 English miles, so that the consumption of coal per mile is as nearly as possible 10 pounds. As, however, considerably more power is required per mile to ascend the line Port Marly to Marly le Roi, the average on the section Rueil to Port Marly will be much less. The weight of engine and train on the two lines is as follows:

| | |
|---|---|
| One engine charged (with brake) | 8,000 kilos. (6,000 empty) |
| One first-class carriage, ditto | 2,200 " |
| One second-class carriage, with Imperial ditto | 3,000 " |
| One van without brake | 2,000 " |
| Average passengers | 3,000 " |
| | 18,260 kilos., or 18¼ tons. |

The result of certain trials recently conducted was as follows: Leaving Port Marly with 15 atmospheres pressure, the train, consisting of the above weights, reached Rueil, after several stoppages to take up roadside passengers, in twenty-four minutes; the pressure in the reservoir being then 8½ atmospheres, or a loss of 6½ atmospheres. After waiting sixteen minutes, during which time no perceptible diminution of pressure took place, the train again started for Port Marly, and accomplished the journey in twenty-two minutes, with a further loss of 4¾ atmospheres, the gauge registering 3¾ atmospheres. The ordinary run from Port Marly to Marly le Roi occupies from ten to twelve minutes, and the return journey about the same. To obtain an idea of the speed of the locomotive and the facilities for stopping, a special trial with the engine alone was made. Leaving Port Marly with 12½ atmospheres pressure, the up journey of 1¼ mile, rising all the way, as before stated, was completed in 5½ minutes, the loss of pressure amounting to 4½ atmospheres. On returning several stops were made on the different gradients with the following results, the average speed being about 13 to 14 miles, the loss of steam only 1 atmosphere, and the time occupied 7½ minutes: Stoppage on gradient of 1 in 18 in 40 feet, stoppage on gradient of 1 in 17·85 in 42 feet, stoppage on gradient of 1 in 16 in 49 feet. The motion of the engine is very steady, and all the gear completely under the control of the driver without his being obliged to move about. The working is as nearly noiseless as possible with quick running machinery. The escape of steam from the funnel, although considerably reduced, is not at any time invisible, even in hot weather.

The machinery is entirely protected at the sides and below by what would in ordinary engines be styled an ash pan, and although the steam is tolerably dry, provision is made for the continuous escape of any condensed steam from the cylinders without the usual noise accompanying the operation. The steam from the reservoir passes into the distributer, with its initial pressure, and is then allowed to expand before entering the cylinders, more or less, according as the train is running or starting, descending or ascending gradients. The permanent way consists of Vignoles rails, with normal gauge laid on sleepers about 80 centimeters apart, and the running is so smooth that, with the ordinary speed on a slightly rising gradient, the train runs 200 to 250 meters after the steam is shut off. The driver actuates the distribution of the steam, and the pressure is controlled by a spring balance, which can be set at any given pressure, and by a gauge. As far as the requirements of this special railway go, the engines so far seem admirably suited to the traffic. The books of the company show a clear saving of 50 per cent. of coal over the original engines with fire boxes, and claim other savings on cleaning, painting, and especially in repairs of fire boxes and tubes. As far as we could see, with a good deal of traffic on the road on which the line is laid, the passage of the train had not the slightest effect on horses or cattle, with the exception of one unfortunate donkey in a cart, which, with the proverbial stupidity of his race, endeavored by a few ungainly gambols to express what looked a good deal more like signs of playful recognition than of fear. That the system is likely to be adopted on other lines is a question we cannot decide. It is true that, once disconnected from the boilers, there is no fear of explosion, nor, under ordinary circumstances, is the stored-up power likely to give out during a trip, not even under the influence of an ordinary protracted delay; still the disadvantages of being entirely separated from the generator, and deprived when out of the end station of the means of reviving lost power, are factors of no mean importance, and we must wait for a longer period of probation than a month before stating definitely that an ingenious and interesting problem has been successfully solved. The openness with which the company afford every facility for examining the details of their invention and the records of the results obtained is a proof that they at least have full confidence in its efficiency, and if they are unable to convince others of the fact, their efforts as exemplified on their own line are evidences of a technical and pecuniary success.—*Engineer*

Fig. 1.




Scale ½o

Fig. 2.




ORE WASHING MACHINE AT THE PARIS EXHIBITION.

## ORE WASHING APPARATUS.

THE ore washing apparatus of which we annex engravings is in operation at the Curzon (Lot-et-Garonne) Iron Works, and is shown at the Paris Exhibition by a model. The arrangement is so simple that it is shown very clearly in the illustrations. It consists of a conical chamber of sheet iron, terminated at the larger end by a short cylindrical length. This drum is mounted on a shaft, and is placed to run at an angle, as shown. Outside the larger end is a hopper, into which the ore to be washed is placed. At the smaller end is a pipe for discharging water into the revolving chamber. The level of the water maintained in the chamber is indicated by the horizontal line on the engraving. Motion is imparted to the chamber by gearing, as shown.

The action of the apparatus is as follows. The ore entering at one end meets the water, the quantity of which is indicated by the transverse section. As the chamber revolves the ore is taken up the sides of the chamber for a certain height, and, of course, at right angles to the axis of rotation, but on reaching a certain point it falls perpendicularly to the bottom of the chamber. By this means the ore is constantly advancing, as shown by the small circles and dotted lines in the drawing. This motion, combined with the effect of the water, completely cleans the ore by the time it reaches the smaller end of the chamber. Before it arrives at this point, however, it passes over perforations made in the plate for the purpose of allowing sand to escape. The ores require to be exposed to the action of the water for about ten minutes, during which time they advance gradually, as indicated above, through the stream of water flowing in the opposite direction. The apparatus at Curzon washes 10 tons of ore per hour; an engine of six horse power is employed to drive it, and to raise the ore afterward to a height of 30 ft.—*Engineering.*

## PROGRESS AND IMPROVEMENTS IN GAS MANUFACTURE.

THE seventeenth annual general meeting of the members of the North British Association of Gas Managers was lately held in the United College Buildings, St. Andrew's, Mr. J. Hall (St. Andrew's), President of the Association, in the chair.

After the disposal of business the President delivered the following address:

We can say of steam, that great motive agent of ours, that it is to-day made, and its hidden power applied, in the same way as when it was first discovered; so will steam always be formed from water by heat; in the same way will coal gas always be got from coal by the application of heat, just as Murdoch got his first sample of coal spirit, as it was called. But let us look at our gas factories of to-day, and then ask ourselves, Have we made any progress? And I think our answer will be, Yes; great progress.

### HISTORY OF GAS LIGHTING.

It is now over 40 years since gas lighting was first introduced into Scotland, and at that time, and for a long time after, it was, in all its departments, in a very crude state. I can remember the first gas retort I ever saw, about the year 1835, was a cast iron one, and that an old teakettle. The engineer and manager of this primitive gas works was Mr. John Young, one well known in the gas world, not only for his own abilities, but through his son, one of this association's most active members, Mr. Young, of Clippens Oil Works, and his son in-law, the late Mr. Cusiter, of Dalkeith, one who, in his short day, rendered good service to the chemistry of gas lighting, and whom this association deemed worthy of notice, and whose death, while yet an active worker, we all regret.

The gas made in this primitive retort was the first display of the wonderful "coal spirit" in a town which now boasts of supplying the cheapest and richest gas in Scotland—I refer to Galashiels, a place dear to me as being the home of my youth. Surely, gentlemen, this beginning was small and crude enough, and I would ask, What is it now?

### PROGRESS OF RETORTS.

Some of you old men, like myself, may remember the form and kind of retort used in the early days of gas lighting—viz., a cast iron retort of a ⊃ form, round on the bottom to fit the arch over the furnace. This is now a thing of the past, except in a few very small works, where the consumption is very variable. There are many other forms of retorts, set in all manner of ways, vertical, sloping, and longitudinal, made of cast iron, and latterly of bricks and clay, in one piece and in several pieces—many of the strange combinations well known to all of us, and to enumerate here would only be waste of time. Clay retorts are now considered to be the best for obtaining good results, and the makers of clay retorts have not been behind in supplying the demand for this article. The perfection to which their manufacture has been brought speaks much for our forward movements; and of late, by means of machinery, these huge clay vessels can be made in one continuous length while green, thus giving them a uniform consistency when burnt—an advantage none of us can fail to see. We, in Scotland, were the first to use retorts of clay, in consequence of the high heats and short charges necessary in the distillation of cannel coal, which destroyed iron retorts very rapidly unless well protected with fire-clay materials, so making settings very costly, both as regards materials and fuel required to heat the mass of brickwork. Of course, at first, many difficulties had to be overcome; but after many experiments and failures, we have the clay retort of to-day.

These retorts are of various forms—⊃ of many sizes and shapes, oval, and circular. For gas making, the ⊃ or oval are the best, but for strength and durability the circular prove the most advantageous. At first the retorts were very carefully built in—so carefully, that I can remember when the late Mr. Taylor, of the Edinburgh Gas Works, then of Kelso, watched and directed every brick and port hole of some of his first works, and had the iron retort guarded all round with fire-clay lumps in case the strong heat should damage them. The gas made per ton of coals from such retorts must have been small in quantity, but I am inclined to think not deficient in quality, giving some cause for the repeated complaints made by consumers, that their gas bills were as small when gas was sold at 12s. per 1,000 feet as they now are when it is half that price. I do not overlook the fact that reduction in price, and a freer use, cause increased consumption, yet I think the complaint is not without cause. Nowadays we have, instead of one or two retorts in a bed or setting, often as many as ten over one fire, built in with fire brick in all manner of ways, according to the ideas of the engineer; and as each of us here, no doubt, has his own plan of setting, it would be useless of me to enumerate any of them, as they are as numerous and various as ourselves. At the same time each of us has the same end in view—viz., to take gas in quantity out of coals. Suffice it to say, that with us in Scotland the most common and, I think, best setting for us is the bed of three retorts. In England, six retorts or seven, in an oven set round one fire, is that most frequently adopted.

Consequent on the use of clay retorts we had high heats, which none of us found fault with, but with them we first knew what choked ascension pipes were; but even for this evil a remedy has been found in larger ascension pipes, these at times surrounded by shields or jackets filled with water, front walls of ovens built thicker to protect the pipe from the heat, and the most effectual of all cures found in the inside "grated door," or, what does equally as well, a plain door, fitting nearly close all round, having a 3 inch opening at the bottom for the gas to pass to the ascension pipe. This door taken out every charge and cleaned is a cure for "choked ascension pipes."

I have not mentioned the "Scott & Young" perpendicular retort, nor many others that have been tried with a continuous charging and discharging apparatus, nor the various means patented or in use for charging and drawing, from the shovel and scoop to the West mechanical and the Foulis hydraulic stokers, and others which, in large works, have been successfully used, and in a measure place the manager above dependence on stokers, who, knowing they are of importance in their own line, at times seek to assert it, to the no small annoyance of those whose anxieties are heavy enough already, and which it should be theirs to lighten; and now we managers have the law specially to protect us against desertion in times of anxiety, but this does not even render us safe; though skilled labor is almost a thing of the past where advantage is taken of the improvements above mentioned.

These few facts, I consider, show progress in so far as retorts are concerned; but I cannot leave retorts without noticing the great improvements made on the lids for closing them. This some may think too small an item to notice; yet, in some works, bad lids and lutes are a great source of annoyance and waste. Nowadays, instead of the heavy cast iron doors which were often as much as a man could lift (and such weight and strength were considered necessary to keep in the gas and withstand the pressure), we have light wrought iron lids, weighing only a few pounds, and requiring only a small quantity of luting, and can be put on and removed with ease. Even this is a step in advance; but we have gone further, and have many patent self-sealing lids, some with ground surfaces, and others with a groove filled with asbetos or zinc, and requiring no luting, hung to the retort mouthpiece, and fixed by a patent eccentric fastening. No doubt this will be a great saving of labor and luting, if they can be kept tight, which is very doubtful, from the fact that though these patent doors and fastenings are used largely in England, they have been tried in Scotland, and, by some, given up. From the difficulty of keeping a secure gas joint, these lids and fastenings can only be used to advantage when there is an exhauster.

In Scotland we use the hinged bridle, and when the spent lime from the purifiers is ground up in a mortar mill, and used for luting the lids, the cost will compare very favorably, all things considered, with the lids requiring no luting

### HYDRAULIC MAINS.

And now, gentlemen, look at the hydraulic main. In its early days we had it small, and of a square form, placed frequently on the retort house wall in front of the bench, having its outlet for gas and liquor at the end into the tar cistern, which was placed underground, and requiring daily attention to keep the passage free for gas. This main, from its position, frequently got pitched up, requiring chisels to clear it out. This gave rise to various expedients to cause the tar, being heaviest, and at the bottom of the main, to flow off first. One plan was a division extending a few inches above and below the water line, to cause a current at the bottom. Added to this was a box projecting below the main, with the same division inside, so as more effectually to insure the flow at the bottom. Again, the small cistern, or, as we may call it, "auxiliary main," at the side or end of the hydraulic, connected to the bottom of the latter with a movable stand pipe, by which the level of the liquid in the hydraulic main could be regulated so as to have the least possible seal on the dip pipes. Then the hydraulic main was in one continuous length, causing great difficulties and danger in repairing, which at times was necessary; and where many dips were required, the seal, when few retorts were working, very often became insufficient, and at other times heavy. Many changes and improvements have taken place here in the form of main, position, and also weight, sheet iron now being largely used in place of the huge cast iron boxes requiring great support. Then we have it cut up into convenient lengths, sometimes one length to every two or four ovens,

each distinct, and having valves to regulate the seal and exit for gas, for which purpose our engineers have furnished us with some excellent valves. Many attempts have been made to do away with or supersede the hydraulic main, and not a few clever and ingenious contrivances have been given us—self-acting or otherwise—for either partially or wholly removing the seal from the dip pipes. Many of us have made trials of such; but none as yet see the advisability of forsaking our old friend the hydraulic, which, when properly adjusted, is, after all, the safest plan; and it seems to me that no just reason for its removal has or can be given, when we lay against it all the risk, expense, and trouble connected with its substitutes. In hydraulic mains we have various plans for regulating the seal of dip pipes, and flow of tar from bottom of the main. I may mention among them Wilson's patent, with its contracted and one-side tar chamber, its divisions between each dip pipe, and its most ingenious but very complicated self-acting "anti-dip reliever."

### GAS CONDENSERS.

And now, passing on to the condensing apparatus, which in the early days of gas making, and even at present, was a very simple yet effective affair, the gas, passing through a series of perpendicular pipes, was cooled, and dropped its cruder matter ere it reached the next stage; and I may say when this condenser is constructed so that the gas can be changed so as to have its entrance and exit from either end, a great amount of cleaning is thereby saved, as the gas when at a certain temperature will keep the pipes clean. Now we have the condenser in many forms, horizontal or vertical. The simplest, and also a very effectual plan, is the wall condenser, which, in many instances, is carried all round the walls of the works, thus saving space, which in most works is not overplentiful. We have also the perpendicular pipe condenser, with the internal air pipes, which gives a large cooling surface to a thin column of gas. The box condenser, with its cross pipes admitting a current of air through them, and the horizontal condenser, built in the form of a screw, so that the liquors formed by condensation are carried along with the current of gas through the whole length of the coil, and in many cases a flow of liquor is kept constantly through these pipes, in some cases with the flow of gas, and in others against it. This seems to be a desideratum of condensation—either to be in the open air or immersed in water; and in some cases underground, with a view to carry the condensed liquors as far as possible with the gas, that these might assist in its purification, by taking from the gas further impurities. One gas engineer says, regarding such a condenser: "We regard this as our best condenser. It does its work most effectively." We, however, hear whispered, "As soon as the gas leaves the hydraulic main, separate it from its liquors, or they will rob the gas of its richest particles, giving rich tar and liquor at the risk of impoverishing the gas, and thus be a fair field for the Aitken & Young process, in converting the crude liquor into rich vapor to be picked up, and enrich the gas by that which should never have been out of it." And while here we are learning we have at the same time made progress.

### WASHERS AND SCRUBBERS.

And now we have washers and scrubbers, such as there were in the early days of gas lighting. These two processes are much alike, and at the present day are combined and included in the head of scrubbers. The first form of washer I can remember was a vessel with a raised chamber at one end, having its cover studded with rows of teeth, through which the gas found its way, agitating the water, and forcing it forward to the raised chamber, that it might return again in a succession of ebbs and flows. This was a washer, pure and simple, which I thought had long ago fallen into disuse, as it caused considerable back pressure, but I find it again revived, and being added to a "patent scrubber." In the early days, vessels filled with brushwood of all kinds, bowlders, coke, and wooden shelves were used, but only in small vessels. Now we have many forms of apparatus for scrubbing the gas—the gigantic tower scrubbers, filled with thin boards of wood or coke, with the ingenious motive power for distributing the liquor over the whole scrubbing material, keeping it moist, and displaying large surface for the finely divided streams of gas. Other scrubbers I might mention, but they are all known to you. I may only say it matters little which one or which form we use, if we can get it to do its work thoroughly, by dividing gas into minute streams, so that if possible every particle of it may come in contact with the scrubbing material, thus robbing it of its impurities; and we may hope to see the day when our ammoniacal liquor, in a certain form, will become our great purifying agent. Already we have taken strides in this direction, and have a patent scrubbing machine, guaranteed to remove all ammonia, and other scrubbers of small dimensions, with arrangements of perforated iron plates, either washed by a shower of liquor or revolving on a shaft and washed in each revolution; thus the gas is very effectually broken up, and without any increase of back pressure.

### GAS PURIFICATION.

Then we come to purifiers, where we get rid of the bulk of our impurities—sulphureted hydrogen, carbonic acid, etc.—and here we can also show progress in no small degree, assisted, no doubt, by the necessity to do something, seeing the removal of the sulphur compounds has caused much trouble and expense, more especially to our brother managers in the south; but, as necessity is the mother of invention, we have had patents and improvements following in quick succession, and yet we have room for more, which, no doubt, will follow, and at last solve the sulphur question. In the matter of purifiers we have made changes in their forms, particularly in their dimensions, also position and working, so as to utilize the purifying material to its utmost, that a saving may be effected. The first attempt at purification, we know, was simply by placing a quantity of lime in a gasholder pit, so that the gas in store might come in contact with it. This was crude enough, but gave us the idea for our first purifier, the wet lime one, which is the most effectual one, however, for the removal of the carbonic acid and sulphureted hydrogen, but the residues of this process are so offensive, and the motive power required to drive the agitators so considerable, that now this form of purifier is of rare occurrence. Then we come to the dry lime process, which is now generally used, and the purifiers for same, and appliances for lifting the covers, which otherwise would be a work of no small difficulty; and valves with which we can control the gas and send it in any direction. In this item alone we have many beautiful appliances which bring our purifier, as far as apparatus is concerned, as near perfection as may be. I remember when purifiers were used without valves, and worked continuous—the first always first, and the last always last; the consequence being that gas making was stopped when they were being cleaned and filled with fresh lime. When we look back and see the former means of changing the passage of the gas to and from the various purifiers, and shutting it off from those vessels by means of the series of side valves attached to the pipes—a costly, inconvenient, and dangerous plan—and the now simple method by means of the hydraulic valve first, of the many forms of faced valves now in use, we cannot help noticing progress great indeed.

Then of late years oxide of iron has become very generally adopted for the purification of gas, even more so in England than with us; not that the process is superior to that of lime for effectiveness, or I question if in many cases it is on the score of economy; but it entirely overcomes the difficulties where the odor from spent lime is found so objectionable, as it is only necessary to use a small quantity of lime to remove the carbonic acid where the oxide is used, and this lime, when spent, has very little smell, if any. Another great advantage in the use of oxide is that it can be used over and over again, until the sulphur forms nearly 40 per cent. of the mass, and then it can be treated by the chemist, who extracts the sulphur from it for commercial use. Patents have been secured, and in some works adopted, whereby the oxide can be revivified without removal from the purifiers. Where this is done a great saving is effected, otherwise the labor account incurred in working the oxide is considerable. But we are promised yet another advance in the purification system, and that in the revivifying of spent lime, or, more correctly, the "recalcining of it," whereby it is again rendered fresh for use. This process has been patented, and, I believe, is in use in several works, giving promise of success, and I trust we may hear something of its working to-day from some gentleman who has either seen the process or practically tried it. All this, gentlemen, looks like progress; but we must not stop here, for it has been said by chemists and eminent engineers that the time will come when gas purification will be conducted in closed vessels, and already we have made, and are making, rapid strides in that direction, not only on the side of progress, but profit.

### EXHAUSTERS AND GOVERNORS.

We have the exhauster and governor, neither of which was in use in the early days. Both are now indispensable in works of any size, and I should say that the latter should never be found wanting, unless, as in some cases, the use of different holders does the work so far satisfactorily. We have many patents, and very clever and serviceable forms of apparatus to choose from; and while we must admit that the exhauster has done much in its own field of labor, yet the governor, in its various forms, has done more, by enabling the manager to reduce the day pressure to a minimum, and equalize the same at other times, thereby reducing the leakage, and giving more satisfaction to the consumers; and as the tendency and wisdom is now to consume gas at a very low pressure, this can only be accomplished by having large mains and services, accompanied with a like increase on internal fittings of all kinds.

### GASHOLDERS.

And, gentlemen, when we come to the gasholder we can certainly mark progress, for by a glance at our large stores of the present day, and those in the early days, when the holders containing a few thousand feet were confined in strong buildings for fear of accident, we, and even the outsiders, have an idea of the advance we have made. And again, looking at the enormous holders now in use, capable of storing not thousands, but millions—and one holder is about being constructed capable of containing over 3,000,000 feet—this, gentlemen, speaks volumes, and shows the advanced state of the manufacture, to which it appears there is no limit, either in make, distribution, or storage.

It has been asked, and made a subject for a prize paper, "Can Gasholders be dispensed with, and what can be substituted for them?" An attempt was made on paper to show how this could be, but the building of such large gasholders, as noted, shows that we are far from the realization of such a result.

### MAINS AND SERVICE PIPES.

Should the day come when we are called upon to supply 18 candle gas, instead of 28 or 30 candle, as we do now, much alteration will be required in our plant, with larger mains and services. This probability should induce us, as I think it already does, to give up the use of small services and fittings, and, if possible, try and control internal fittings so far as we can; and at least we can give our advice, knowing that, to secure a good supply and proper combustion, the pipes to this point cannot be too large, or the pressure with our many improved burners too light. I myself do not think that, as far as Scotland is concerned, it is likely such reduction in illuminating power will be necessary, or be desired, as we find consumers in general are prepared to buy light rather than gas, and from this fact we would gather that our work and duty as gas managers is to devise and adopt any and all means that will enrich our present gas from our present materials, and see that our consumers use the burners we know are best suited for its proper combustion, so as to get out of a given quantity the full amount of light profitably, not losing sight of any improvements in the various apparatus, so that the quantity may be increased, and a good and cheap light secured for the public. And I would not say that at present they have anything to complain of. Gas has been sold at 12s. and 16s. per 1,000 cubic feet when coals of the first quality could be bought for 18s. per ton; it is now sold at 4s. 6d. and 5s., when the same coal sells at nearly double the former price. This, again, gentlemen, is progress, without doubt.

### SUBSTITUTES FOR GAS LIGHTING.

We have heard of late much about the electric light, and many fears have been expressed as to the probability of its superseding the use of gas, and I believe it has been the means of, in a way, checking the anxiety of corporations to possess the mines of wealth supposed to belong to gas concerns. Certainly science has of late done much for this new means of lighting, but has yet much to do ere we will see the electric lamps by our hearths. There is a large field and ample room for both gas and electricity; the latter can light our lighthouses, large buildings, open spaces, ships, or battle fields, but much has yet to be done ere we can hope to see any general use made of the lamp, the difficulty being in diffusing such light, or dividing it up into convenient streams to meet the varied requirements of light. Gas possesses this power of distribution, and has added much to the success of our present gas system. One advantage has been claimed for the electric light, and that is the absence of heat. As to this being an advantage, I am doubtful; but it is certainly an item in favor of gas, for if it should ever come to pass that we have to take our stand in the background for light, we can supply heat, do away with much of our troublesome purifying and scrubbing apparatus, and supply a cheap gas for heating and cooking purposes; and by developing the use of gas in this way as we have done in the other, our concerns will still be as successful and profitable, if not more so. But this is a dream; we may realize it, but the time is yet far off; and it would take many years to weaken the hold gas has got as a necessity of life at the present day.

### GAS ENGINEERING IN GENERAL.

It may be admitted by some (for myself, I do not admit it) that some manufactures have made more progress than gas; but I trust, by these few commonplace remarks, that I have shown cause for my obstinacy. Be it as it may, I do not think it is because gas engineers or managers have been remiss in their duty, or behind others in point of intelligence or energy, as can be seen, even from the patent list of past years. We must look somewhere else for the reason. Say, can it be the nature of the subtle element we have to deal with, and work on, and produce? The study and chemistry of gas lighting is a subject more fitted for the university class room than for the manipulations of a manager who has to perform the duties of engineer, manager, secretary, treasurer, and, in many cases, meter inspector, and collector, with, possibly, the one demand from his employers—viz., "a good dividend." It may be bad managers got more encouragement, and were allowed to reap some of the fruits of their hard labors. In most cases this means a life of incessant toil, sleeping in harness, with the anxiety of long nights and short stores of gas. Only gas managers can know this feeling, when, as it were, the whole population seem to hang on them for support, and they know not of it. This anxiety, any many others, can hardly be paid in money value; and when things take certain turns, and labor is undervalued, can we wonder if energy does lack prominence in some cases? In these days of high wages and short hours, gas managers have not, I think, been found among the agitators, but, as a class, have labored; and certainly we can every one of us say with all truth we have not "receded."

### SUBJECTS FOR DISCUSSION.

The subjects to be brought before this meeting, as announced to you by circular, are all of an interesting character, and are as follows, viz.:

1. "How should the Illuminating Value of Gas be Determined?" By Mr. A. Macpherson, Gas Works, Kirkcaldy.
2. "The Necessity for a Proper Control over the Pressure of Gas for Illuminating Purposes." By Mr. A. Mitchel, Gas Works, Dundee.
3. "Governors for Lamps and Stair-lights," with a description of an Improved Metallic Governor, which will be shown in action. By Mr. D. Bruce Peebles, Edinburgh.
4. "A Graduatory Method of Condensing, Washing, and Purifying Coal Gas by a Combined System of Rotary Apparatus." By Mr. D. M. Nelson, Glasgow.

In addition to the foregoing papers, the following apparatus is placed on the table for your inspection, viz.:

One 2 inch Foulis Governor, with Bye-pass arrangement.
One Foulis Patent Automatic Lamp Lighter.
One Foulis Patent Dry Governor.
One Foulis Patent Lamp Regulator.
One Experimental Meter with Warner & Cowan Drum.
One Warner & Cowan Meter with Glass Drum.
Two 20 inch Pressure Gauges.
Three 12 inch Pressure Gauges.
Two Thermometers for Condensers.
One Dry Show Meter.
Two Inspectors' Pocket Pressure Gauges in cases.

These apparatus you will examine, and judge of their adaptation for the work they engage to perform; they are not placed there as an advertisement, but for your instruction, and as a further corroboration of the fact that gas making and gas apparatus have made very great progress.

## ARTESIAN WELLS.

IN Iroquois County, Ill., eighty-five miles south of Chicago, 53,500,000 gallons of flowing water from artesian wells are daily supplied for irrigating land. No well is over 75 feet deep. There are 200 wells within a radius of twenty miles, all of small bore. The prairie is 90 feet above Lake Michigan, and there is no high land for 200 miles which can furnish a fountain-head to these wells. Paris derives a flowing current of 6,000,000 gallons from two such wells. Three more wells are now being sunk, which, with the old ones, will give a subterranean supply ample for 3,000,000 inhabitants. A correspondent of the Baltimore *Sun* says that engineers are confident the artesian river flowing under San Francisco, leading direct from the exhaustless lakes of the Sierra Nevada, is quite adequate to supply several cities of its size.

## LABOR IN WALES.

WILLIAM WIRT SIKES, Consul at Cardiff, reports to the Department of State under date of June 29, 1878, the following statistics and facts relating to trade and labor in Wales: "Farm laborers can earn from $1.50 to $3.50 per week, varying in different counties more or less distant from railroads. Privileges of house-room and beer may be added to the wages. In towns brickmakers earn $2.50 to $7.50 a week; ship carpenters, $1.62 a day; coopers, $1.12; engine drivers, $1.25 to $2; firemen, $1 to $1.12; laborers, 10 cents per hour; painters, 14c.; masons, 16c.; carpenters, 16c.; plumbers, 15c.; plasterers, 15c. an hour. The cost of living averages from $3 to $5 a week for a family. There is a fair amount of thrift among this class, who are, however, somewhat given to jollification, especially those not of Welsh blood. It is an important fact that the wives of laboring men fill a more active place in the bread-winning scheme than women do in America. Many go off to their work every morning of their lives as regularly as their husbands. They are also very frequently the treasurers of the marital firm, keeping the weekly outlay for jollification as near the minimum as possible. Among the occupations of women are letter-carriers, peculiar to Wales. Benefit societies called the 'Friendly Sisters' prevail among the women. The cost of living in Wales would be somewhat higher now than in 1873 were it not for the importation of American beef, canned meats, vegetables and fruits. This potent influence has not only reduced the cost of living, but has given an impetus to trade and competition. The poorer classes have profited by this movement more than others. Meantime, the rate of wages has decreased and the tendency is downward. Trade throughout the district is in a very depressed condition. There is much distress among the laboring classes for want of employment. The Welsh laborers, as a class, are thriftier than the Irish or English. In some parts of Wales the habits of the people are still primitive. Wages are there nominal and the cost of living proportional."

## HISTOLOGY AND THE CELLULAR THEORY.

By DR. EDOUARD FOURNIÉ.

Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the *Gazette des Hopitaux*.

### II.

IF we except these singular peculiarities about the constitution and development of cells, and some other peculiarities whose falsity was demonstrated by Vogt and Coste, Schleiden advanced, concerning the transformation of cells into fibers and tubes, the same ideas as De Mirbel, Turpin, and Dutrochet.

Schleiden had only applied his theory to the birth and development of vegetables. Schwann, some time afterward, applied this same theory to the birth and development of animal tissues. Acquainting himself with the first works of De Baer and Coste on the egg of mammals, Schwann considered this last as a primary cell developing itself like the vegetable cells of Schleiden: the germinative spot should be the nucleolus, the germinative vesicle should represent the nucleus, and the vitelline membrane should be the wall of the cell [1]

As regards the cells themselves, he made them arise from the amorphous substance in the middle of which the cells are found, and which he designated for this reason by the name of *cytoblastema*. The formation of cells, says he, is to organic nature what crystallization is to inorganic nature. Aside from that, Schwann admits that all the tissues arise from cells more or less transformed, and subdivides them in the following manner: 1st. Isolated, independent cells (lymph, blood, mucus, pus); 2d. Independent cells, forming by their union a united tissue (epidermis, corneal tissue, crystalline lens); 3d. Cells whose walls only are united among themselves (cartilage, bone, teeth); 4th. Cells of connective tissue (cellular tissue, elastic and aponeurotic structures); 5th. Cells whose walls and whose cavities are mingled together (nervous tissue, muscles, capillary vessels).

Such are the fundamental principles of the cellular theory according to Schwann. It is easy to prove that this theory is only the development of the ideas of Dutrochet; but Schwann undoubtedly had the merit of placing this hypothesis on a large number of facts, and he was considered, with some show of reason, as the true founder of the cellular theory. Schwann had discovered nothing, but it is just to say that his works impressed on the whole of Germany a salutary impulse toward microscopic researches.[2]

Later works, though confirming certain general views of the cellular theory, such as, for example, the formation of the embryo by cells,[3] did not delay to invalidate the views of Schwann in what is most fundamental, that is to say, in the formation itself of the cell and in the conditions of its development.

Coste proved that the ovarian cell was not developed as was thought by Schwann.[4]

Vogt and Bergmann demonstrated that the cells are derived from segmentation of the vitellus, or from other cells, and Vogt was able to affirm that in certain cells of cartilage the cell develops before the nucleus.[5]

Vogel, Goodsir, Kölliker, Luschka, Bischoff, Donders, etc., proposed new explanations concerning the formation of cells. Then came Remak, who, criticising all these explanations, and only accepting from Schwann what was fundamental in the conception of the cell, professed that *every cell comes from a pre-existing cell*, or by *endogenous* formation. Thenceforth the theory of *equivocal* generation of Schwann was no longer admitted. But that of *continuous development*, inaugurated by Remak, was scarcely preferable, though it was more in accord with the progress of science. Remak, more enlightened than his predecessors by the recent discoveries of embryologists, established a complete analogy between the cells of the ovule, and adopted for the generation of the first a mode analogous to that of segmentation of the vitellus. The discovery of the embryogenic vesicle of Balbiani has since shown that the ovule is not as simple as Remak thought it. But in contemplating the infinitely small, the imagination has wide scope. Remak did not rest there, and, supported by embryology, he admits this other hypothesis, *that all the tissues come from embryonic cells*—that is to say, from the external, middle, and internal layers of the embryonic nest of the blastoderm. It appears, indeed, very natural that our tissues take their origin from a common source, and the embryonic cells soon arrive at a point when they can sustain the latter.

Unfortunately, M. Robin has shown that very many of the tissues, very many of the organs, are developed when the embryo no longer presents a trace of cells of vitelline production.[6]

The cellular theory was in this period of its evolution when Virchow appeared.

"M. Virchow," says M. Broca, "has a great deal of ability. He manages with skill a language that he knows how to render clear or obscure at will, according to the exigencies of the idea he is exposing. A passionate worker, endowed with an imagination full of resources, he excels in finding new points of relation, in bringing about reconciliations imperfectly seen by his predecessors, in turning to his side by ingenious interpretations facts that would oppose his views, in clearing up the unknown by the unknown, and in simplifying everything by his transcendent productions. Then he has confidence, which gives tenfold force to a man, and eradiates around him on all those who approach him. He believes in a unity of organization, an absolute unity; it is to him a dogma, a principle of superior order which holds the solution of every problem, and it is wonderful to see with what fecundity of invention he discovers between the most dissimilar things points of similitude, with what force of induction he concludes that these things are analogous, with what power of abstraction he transforms this analogy into identity."[7]

The irony with which this sketch is drawn reproduces exactly the *silhouette* of the man who, in these later times, has given himself out as the second inventor of the cellular theory.

We should consider two things in the works of Virchow, the physiological and the pathological theory. As the latter flows from the former, we will only speak in this place of the physiological theory.

The ideas of Virchow upon this subject may be summarized in the following propositions, which we have chiefly taken from the "Cellular Pathology" of the author:

"1st. The cell, to deserve that name, should necessarily be composed of two parts: an enveloping membrane, which may be round, angular, stellate, etc., and a nucleus, which possesses in chief a different chemical composition from that of the membrane."[8]

The starting point of Virchow rests on an error of fact. All cells, in truth, are not essentially composed of a wall, as Schwann, Remak, and, in the last place, Virchow have said. For a long time it had been settled in France that very many cells have no wall.

Dujardin had pointed out the absence of a wall in some inferior unicellular beings, and composed of a simple mass of *sarcode*, designated since by the name of *protoplasm* by Reichert and Mohl. In examining with the microscope living worms, he had also proved that there escaped from the body of these animals, by pressure, a globular substance capable of modifying its form and of undergoing expansions. Dujardin gave to these various masses the name of *sarcodic* globules.[9]

Coste, in 1845, demonstrated that most of the cells that arise from segmentation of the vitellus have no wall.[10] These facts were not generally accepted; but in 1861 M. Schultz proved the absence of a wall with many unicellular animals that he designated by the name of *amœbas*, and he gave to the movements of these animal cells deprived of a wall the name of *amœboid* movements.[11] These same movements had been called *sarcodic* in 1838 by Dujardin. In 1862, Brücke demonstrated these same facts. Finally, thanks to the more recent works of L. Beale, of Van Beneden, and of Ch. Robin, we know to-day that many cells of the human body are deprived of enveloping membranes—embryonic cells, the white globules of the blood, etc., etc.

The error of Virchow and of his predecessors concerning the constitution of cells has no very great importance, for the masses of protoplasm that they designated by the name of cells existed none the less; but the invention of the word *cell* is unfortunate, for this word, to be well understood, requires a new definition.

"2d. In pathology, as in physiology, we can lay down this great law—there is no new creation; it is no more true of complete organisms than of particular elements. . . . We deny the possibility of the formation of a cell from a non-cellular substance. A cell presupposes the existence of a cell (*omnis cellula a cellula*), just as a plant can only be derived from a plant, and an animal from another animal."[12]

Virchow professes with Remak that every cell comes from a cell, and, being unable to demonstrate his assertion by anatomical proofs, he must bring in the theory of non-spontaneous generation, which should find itself very much astonished at being concerned in such an occurrence. Since M. Virchow believes in creation, he believes also in a creator. This conviction honors him, and allows us to reply to him that nothing can be demonstrated *scientifically* if the creator has created everything on that principle, or if he dispenses his power little by little by applying it daily to the creation of new species.

Moreover, that which created animals, has it not been able to create at the same time the conditions of the medium which allows the spontaneous development of certain species that we consider as new? We have connected ourselves with this mode of viewing it, and we hope that it will be that of every one, the day when we shall know better the invariable conditions of existence and of reproduction of all living beings.[13] While waiting we willingly recognize that scientific data are in general little favorable to spontaneous generation, and we add that to affirm what *may* be true on this point is to venture a hypothesis that rests entirely on the *possible* determinations of the creator.[14] The affirmation of M. Virchow is not then a proof.

All this may be said in passing, for the generation of cells has absolutely nothing to do with the theory of spontaneous generation. M. Virchow has been able to call in to the support of his position *omnis cellula a cellula*, non-spontaneous generation, because he supposed implicitly that a cell forming a constituent part of the living body might be assimilated from a vegetable or an animal. Nothing legalizes this assimilation, which is weightier than we might think at first sight.

There exist, it is true, unicellular animals which offer the greatest analogy to the cells of the living body. The field of this analogy is very largely increased, since, contrary to the definition of Virchow, it has been discovered that very many cells of the living body have no proper envelope. It is thus that the *cytodes* of Haeckel, composed of a mass of finely granular homogeneous substance, without nucleus and without proper wall, may be likened to the polar globules of the ovule of various vertebrate and invertebrate animals.[15] It is thus that the *lepocytodes* of Haeckel, formed at first of protoplasm, may surround themselves with an envelope at a certain period of their existence, which allows them to be likened to *leucocytes*.[16] It is thus that the *gymnocells* of Van Beneden, constituted of protoplasm without envelope, and by a nucleus, may be likened to most of the cells that come from the segmentation of the vitellus. Finally, by slightly forcing the comparison, we may say that the reproduction of *gregarines* by metagenesis may be compared to the reproduction of the ovule in the embryo. These analogies, these likenesses are possible when we look superficially at certain characters, morphological or others; let us speak better, they have a very peculiar charm for the imagination.[17] But a more careful examination does not allow us to accept them.

From the point of view that we occupy, morphological characters have a mediocre importance, because, in the world of infinitesimals, organized living matter assumes forms slightly varied and nearly identical—tubes, fibers, globules.

It is the same with chemical characteristics, which may be very precious in order to distinguish the various elements of the same organism, but which cannot be of any aid when we wish to know whether one little piece of organized matter represents an individual or whether it forms a constituent part of an organism. To establish this distinction or this likeness we must have recourse to a physiological criterion, that is to say, to the vital manifestations of the organized matter. In other words, it is neither the form nor the chemical composition that enables us to say whether the matter represents an individual or only a simple element. The aggregate of the vital manifestations can alone enlighten us thereon.

The vital manifestations that present themselves, on the one hand, in the cells of the organism, on the other, in unicellular animals, offer numerous analogies; and it must be that it should be thus, since we cannot establish any characteristic differences between them.

Meanwhile these things exist. We willingly admit that the cells of the organism, like those of the amœbas and other unicellular animals, subsist in the state of living elements by the endosmotic absorption of nutritive principles; we admit even that leucocytes and epithelial cells incorporate *by envelopment* the various elements. We further admit that, like the unicellular animals, organic cells are reproduced by segmentation, fission, etc. We finally admit that organic cells, ever analogous to cellular animals, may contract themselves and move. It is true that we might add some points of difference to each of these likenesses; we might say, for example, that each organic cell does not present the mouth and œsophageal duct that we meet with in the ciliated infusoria; we might say further, that it is not at all proven that in the embryonic evolution of many unicellular animals we can liken the nucleus of the latter to the nucleus and to the nucleolus of cells in general; we might say finally, that if leucocytes contract, and are capable of a seeming migration, it is not every organic cell that presents the contracting vesicle of the amœbas, and, like the *flagellate infusoria*, the *flagella* have voluntary movements. But these points are of slight importance.

The essential point, in our opinion, is to know whether these phenomena that present such analogies among themselves are of the same nature, of the same order. That is the question. I answer, No! The vital manifestations of organic cells and those of unicellular animals are of an entirely different order. This is what we shall now prove.

*(To be Continued.)*

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[1] Schwann, "*Mikroskopische Untersuchungen ueber die Uebereinstimmung in der Structur und dem Wachsthum der Thiere und der Pflanzen.*" Berlin, 1838.

[2] After what we have said, should we not be astonished to read in the "*Traité d'histologie et d'histochimie*" of M. Frey (of Zurich) that "it is to Schwann that the honor belongs of having first considered the cell as the starting point of the whole entire body" (p. 73)? We should be no less astonished to read in the "*Manuel d'histologie pathologique*" of MM. Cornil and Ranvier "that histology, founded by Bichat (this, for instance, is new), has received its full development since Schwann applied to his studies the results discovered by Schleiden in vegetable tissues" (p. 1). How comes it that M. Ranvier, who himself is without doubt destined to become one of the greatest authorities on microscopy, cannot be more just in regard to those who have preceded him in his own native country?

[3] Reichert, "*Entwickelungs-Leben im Wirbelthierreich.*" Berlin, 1840.

[4] Coste, "*Histoire generale et particuliere du developpement des corps organises.*"

[5] Vogt, "*Developpement du crapaud accoucheur.*" 1842.

[6] Robin, "*Anatomie et physiologie cellulaires,*" p. 346 *et seq.*

[7] Broca, "*Traite des tumeurs,*" vol. i. p. 58.

[8] Virchow, "*Cellular Pathology,*" p. 10.

[9] Dujardin, "*Infusoires.*" 1841.

[10] Coste, "*Comptes Rendus de l'Academie des Sciences*" 1845.

[11] M. Schultz, in "Reichert's und Du Bois-Reymond's Archiv." 1861.

[12] *Loc. cit.*, p. 23.

[13] In these later years science has made such progress on this point, that the time is perhaps not far distant when we shall be able to give the formulæ of all the conditions that preside over the development of life.

[14] Edouard Fournie, "*Physiologie du systeme nerveux,*" chapter "*Place de l'homme dans la nature,*" p. 786.

[15] Robin, *loc. cit.*, p. 4.

[16] Robin, *loc. cit.*, p. 4.

[17] It is an attraction of this kind that inspired Geoffroy Saint Hilaire when he pretended that the human fœtus passes through transitory states recalling the definite state of different beings which are inferior to it in the animal series. Serres, who partook of this view, formulated it in these terms: "The development of the human organism is a transitory comparative anatomy, as in its turn comparative anatomy is the fixed and permanent state of the organic development of man." (Serres, "*Precis d'anat. transc. appliquee a la physiologie,*" p. 90.)

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## TEMPORARY KLEPTOMANIA.

By HUGH MILLER, M.D., Physician-Accoucheur, Glasgow Maternity Hospital.

MY patient was the daughter of a person in comfortable circumstances, who came to town to finish her education, and while there she resided in a house with other young ladies of her own age, chiefly boarders also. Already she had lodged nearly two years there, and hitherto she had suffered from no sickness. The first occasion on which she was absent from school was the illness for which I was called to attend her. Before I saw her she had suffered from toothache, and on the day previous to my first visit she had consulted a physician, who, to relieve her, had extracted one of the right lower molar teeth. I am unable to say whether the consequences were due to lack of skill on his part or to a diseased condition of the gums then present. The extraction of the tooth failed in giving her relief, and when I visited her I found her suffering from very severe pain in the lower jaw, extending back to the ear, and having occasional agonizing paroxysms. Opiates were administered, giving partial relief, but any treatment proved only palliative until a third piece of necrosed bone separated and was extracted. The case is chiefly interesting from certain mental peculiarities which developed during the period she suffered pain, and which terminated with the throwing off of the diseased bone. My attention was first called to it through finding the landlady one day in a state of excitement over the discovery that several small sums of money and two or three trinkets had been abstracted from the wardrobes. Her servants had been with her for years, and she had entire confidence in their integrity. From the peculiar mode in which the missing money and the jewels had been abstracted I stated my belief that the young lady might be the offender. I advised the landlady to make a thorough search in that direction before taking any legal steps. She did so, and in my patient's wardrobe she found sufficient evidence to criminate her. It was also found that she had taken no special means to secrete the articles, as the missing ones were found beside her own ornaments. On ascertaining this I charged the young lady with the offense. At first she firmly denied it, and maintained her innocence with an apparent dignity and candor which surprised me. When challenged with the various articles removed her apathy changed to surprise, and she gave me the notion that she was realizing for the first time the possibility that she might have done it. It was only when it was made plain to herself that her peculiar conduct had been observed that she admitted her offense. Afterward there seemed to be a gradual dawning of shame and of regret; then a confused look, after which she began to cry. She never once spoke of the dread of her family being disgraced by what she had done, and there was no tearful appeal for mercy and for silence. She was next requested to write down all the sums of money and the various articles she had removed. She frankly did so, and her statement corresponded with the missing money and jewels. She at the same time settled how the various sums abstracted were to be repaid. Within an hour of her being charged with the theft she had tea, and ate heartily.

From the patient I afterward learned that while ill and in pain she had gone to her companions' wardrobes while they were at school, not, she thinks, from any covetous desire, but rather from an impulse to have her mind agreeably employed. I believe it was at first from curiosity—a desire to pry into her companions' boxes—that she was led to make the search. What suited her fancy in ornaments she took and placed among her own, and when she met with a purse she took a small portion of the money. The most of the money removed in this way had been spent either in sweets or in fancy articles, which, as a rule, were given as gifts to the companions from whom she took the money.

The desire to pilfer had never been observed before the onset of her painful illness, and from the time the inflammation ceased, and opiates were unnecessary, she showed no disposition to resume her peculiar habits.—*Lancet.*

## THE ANTIDOTE FOR MERCURY AND LEAD POISONING.

M. MELSENS, Professor of Chemistry at Brussels, has just been the object of a new honorary distinction. A prize of $2,000 was offered in Belgium by Dr. Guinard to "the author of the best work, or of the best invention, for bettering the material or intellectual condition of the laboring class."

It is well known to what dangers certain classes of artisans are exposed, who are obliged in some branches of manufacturing industry to handle mercury, lead, and their derivatives.

The prize was awarded to Professor Melsens for a method of combating the effects of poisoning due to absorption of the poisonous emanations from these metals (or for preventing such poisoning entirely), by the use of iodide of potassium. Affections of this nature are caused by the presence of insoluble metallic compounds in those organs which are the seat of the disease; iodide of potassium transforms these insoluble into soluble compounds, which may then be expelled from the system.

For a long time iodide of potassium has been considered as a true poison; Professor Melsens begins by proving that this medicine is harmless, on the essential condition that it be perfectly pure, and that it be administered in small, then gradually increasing doses. The administration of large doses to poisoned persons would produce in the economy a quantity of soluble double salt, considerable enough when drawn into the circulation to produce an ordinary case of true poisoning.

The insoluble compounds of mercury, as well as those of lead, are readily transformed into soluble compounds by the aid of alkaline iodides, and these soluble bodies are eliminated by the secretions of the body. Sulphate of lead, which is very slightly soluble in water, causes the death of animals, and is as dangerous to handle as carbonate of lead and all other insoluble salts of this metal. All these bodies are eliminated through the action of iodide of potassium, which clears the system of them and prevents their deposition in the organs, when it is administered in suitable doses.

The Academy of Sciences of the Institute of France had, previous to the action of the Belgian jury, awarded the Montyon prize to Professor Melsens for the same work, the importance of which will be recognized by all physicians.

## MILK A SOLVENT OF QUININE.

ATTENTION has recently been called to the fact, not generally known, that milk not only acts as a solvent of quinine, but also to a certain extent disguises its bitterness. It is stated that if one grain of the sulphate be dissolved in an ounce of milk, the bitterness of the salt is scarcely perceptible, while even two grains in the same quantity of solvent do not make it bitter to a marked degree. Five grains may be taken in two ounces of milk without rendering it particularly disagreeable, and if this be added to a tumblerful of milk, nearly all the bitterness disappears. The resident surgeon of the Birmingham General Dispensary recommends the use of a solution of quinine, in glycerine, in the proportion of one grain to one drachm—the dose being administered in a wineglassful of milk. The method would seem to present especial advantages in the administration of quinine to children.

## CHEMICAL NEWS NOTICES.

*Glycolide.*—J. H. Norton and J. Tcherniak.—The authors adopt the following method for the preparation of glycolide. They dissolve sodium in 15 parts of absolute alcohol, and add a concentrated alcoholic solution of chloracetic acid. After standing for some hours almost the whole of the sodium chloracetate separates as a white precipitate. This is collected upon a funnel, drained by means of a filter-pump, and dried. It is then heated to 100° in a stove, and when perfectly dry the temperature is gradually raised to 150°. It is well to spread out the salt over large flat surfaces, stirring from time to time. After thus heating the salt for two days it is withdrawn from the stove, powdered, and taken up again with boiling water, thrown upon a filter, and washed as long as the washings are precipitated by nitrate of silver. The residue, dried at 200°, is perfectly pure glycolide.

*Ammoniacal Citrates.*—E. Landrin.—The author examines whether the citrate of ammonia acts merely as a solvent upon metallic oxides, or if it enters into direct combination with such oxides. The citrate of lime, insoluble in water, is soluble in ammonium citrate, and it is the solubility of this salt which hinders the precipitation of lime in Joulie's analytical process. On the other hand, magnesia, alumina, and ferric oxide form, with citric acid and ammonia, well-defined compounds, which have the general character of not precipitating phosphoric acid. Similar compounds are also formed by the oxides of manganese, nickel, cobalt, and copper.

*Quinonoid of Agaric.*—W. Thörner.—A tinctorial substance of the composition $C_{11}H_8O_4$ has been obtained by extracting *Agaricus atratomentosus* with ether. The crystals left on the evaporation of the ether after purification form dark brown scales of a metallic luster, soluble in boiling alcohol or glacial acetic acid, with a vinous red, and in alkalies with a greenish-yellow color.

*Iodine Phenols.*—H. Kämmerer and E. Benzinger.—If iodine, dissolved in potassic iodide, is added to saturation, hot, and very dilute alkaline solutions of the phenols, precipitates are obtained interesting on account of their insolubility in water and their characteristic coloration. Phenol itself gives a red precipitate, thymol one of a faint violet color, and commercial creosote at first a greenish-brown fluorescent solution and finally a voluminous dirty-brown precipitate. The authors have made a special examination of the products of the reaction of phenol and iodine.

*Thymol.*—L. Barth.—Four acids are obtained by the action of melting potassa upon thymol. Two of them are well known, oxybenzoic acid and oxyterephthalic acid. The third, thymol-oxycuminic acid, has the composition $C_{10}H_{12}O_3$, and crystallizes in fine, colorless, brittle needles, sparingly soluble. The fourth, thymolic acid, $C_{10}H_{10}O_3$, is readily soluble in water, and precipitable by sugar of lead from this solution. It yields an intense red coloration with ferric chloride, and appears to be bibasic.

*Acetic Ether.*—F. Allihn.—On cautiously adding acetic ether to sulphuryl chloride, large quantities of sulphurous and hydrochloric acids escaped, and a yellowish liquid was obtained, which, when freed from acids, distilled over between 205° and 208°, and agreed with Conrad's di-chloracetic ether. By using only one molecule sulphuryl chloride to one of acetic ether, a mono-chloracetic ether was obtained.

*Glucinum.*—Lothar Meyer.—The author criticises the result of MM. Nilson and Pettersson, contained in the last issue of the *Berichte*. He remarks that an element of the atomic weight $G'' = 13{\cdot}8$, would find its place between C = 11·97, and N 14·01 in the systematic classification of the elements developed by Mendelejeff and himself,* where a trivalent, metallic, or semi-metallic and moderately infusible element would not suit. It is, therefore, highly probable if glucinum is really trivalent, that its equivalent weight, as determined by Awdejew, is too high (4·6 glucinum equivalent to 1 hydrogen), and that its atomic weight is not $3 \times 4{\cdot}6 = 13{\cdot}8$, but must be below that of carbon and above that of boron, or between 11 and 11·5. With this atomic weight it would form the first member of the aluminum group, with a regular difference of 16 units from the second member (Al = 27·3). Boron, hitherto placed along with aluminum, would form the initial member of a separate group, so that in future we should have to admit between that of the alkaline earths and that of nitrogen, not two, but three groups—those of boron, of glucinum, and of carbon. The three elements, cerium, lanthanum, and didymium, with the respective atomic weights 137, 139, and 144, would rank as higher members of these three series.

*Synthesis of Oxindol.*—A. Baeyer.—Phenyl-acetic acid is treated in the water-bath with fuming nitric acid; the resulting mixture, after the expulsion of the nitric acid, is reduced with tin and hydrochloric acid, and the liquid is concentrated after the tin has been precipitated with sulphurcted hydrogen. The acid liquid is neutralized with carbonate of lime, and boiled for a short time with precipitated carbonate of baryta. The isomeric amido acids form salts of barium, which the ortho-acid does not, as it remains in solution. Ether extracts it at once in a pure state, when it may be recognized as oxindol.

*Transformation of Spectra.*—H. W. Vogel.—It is well known that the absorption bands of one and the same substance, if dissolved in various solvents, have not always the same position. Kundt proposed the law that the absorption-bands lie the further toward the red the greater the refractive power of the solvent, and this law holds good in many cases. On the other hand, examples are known where, on change of the solvent, the bands move neither toward the red nor the violet, but the whole character of the spectrum is modified without any chemical action of the solvent upon the dissolved body. After mentioning the modification in the absorption spectrum of purpurin accordingly as dissolved in alcohol or water, and of brasilin and hæmatoxylin in ethereal or aqueous solution, the author gives an account of his recent researches on the spectra of naphthalin red in alcohol, in water, in the solid state, and on paper.

*Reagent for Nitrous Acid.*—P. Griess.—The author had previously recommended diamido-benzol as a reagent for nitrous acid, capable of indicating its presence even when diluted to the extent of 1 part in five millions. He now finds that meta-diamido-benzol, which is more easily procured, is a still better reagent, showing nitrous acid even in 10 million parts of water.

C. Preusse and F. Tiemann, having examined the above-mentioned method of P. Griess, find that it is practicable in case of dilute solutions. Stronger solutions must be diluted with water free from nitrous acid, just as is required in the application of Nessler's test to ammoniacal solutions. The requisites for the process are: a dilute solution of meta-phenylen-diamin, prepared by diluting 5 grms. of this base in 1 liter of water, and slightly supersaturating with dilute sulphuric acid. A dilute sulphuric acid formed by mixing 1 vol. pure sulphuric acid with 2 vols. distilled water. A solution of alkaline nitrite, 1 c.c. of which contains 0·01 mgr. $N_2O_3$. To prepare this, 0·406 grm. pure, dry silver nitrite is dissolved in hot water, and converted into sodium nitrite by the addition of pure sodium chloride. When cold, the solution is made up to 1 liter, let stand till the silver chloride is perfectly precipitated, and 100 c.c. of the clear liquid are again diluted to 1 liter. After a careful examination of this and of other processes, the authors conclude that, in all waters which cannot be perfectly decolorized, the method with zinc iodide and starch is preferable, after the absence of iron compounds has been ascertained.

*Silvering Glass.*—M. R. Böttger.—Tartrate of silver in very fine powder is suspended in distilled water, and very dilute ammonia is then very carefully added until the tartrate of silver is dissolved. The operator must satisfy himself that a small excess of the silver-salt remains undissolved, and that the liquid gives off no ammoniacal odor. Into this bath the objects to be silvered are plunged, having been first carefully cleaned. In about ten minutes they are covered with a uniform layer of silver.—*Deutsche Industrie Zeitung.*

*Indigo.*—M. Alb. Scheurer.—Indigo exposed to the oxidizing action of a mixture of caustic soda, and of potassium ferricyanide, is at once destroyed. The same reaction is obtained on steaming a vat-blue tissue, upon which has been printed a mixture of ferricyanide, mixed with any acetate whatsoever. Among the acetates, that of lime is the most efficacious. Potassium ferricyanide printed upon a medium blue, along with ammonic sulphate, destroys the indigo, and gives rise to Prussian blue, which, on passage through weak soda, disappears, and gives place to white. Bichromate of potassa, in presence of a metallic sulphate or chloride, and under the influence of steam at 100°, destroys indigo, with the simultaneous production of chromic oxide, chromate of chrome, and chromate of the metal employed.

*Magnesite* is proposed in place of chalk as a material for the evolution of carbonic acid in soda water manufactories. The residue is to be employed in the manufacture of magnesium sulphate.

*The Chromates.*—F. Morges.—The heat of combination of anhydrous chromic acid with water has been in the first place determined—

$$CrO_3 + H_2O \text{ at } 19{\cdot}5^\circ = CrO_4H_2 = +580 \text{ cals.}$$

This result is far below that for sulphuric anhydride, for which the mean of the numbers found by M. Berthelot and M. Thomsen is 20,850 cals. This difference is explained if we remember that anhydrous chromic acid crystallizes from its aqueous solution. The regular curve which represents the thermic phenomena of the hydration of chromic acid presents at $4H_2O$ a maximum ordinate which seems to indicate the existence of a hydrate of chromic acid.

*Artificial Production of Carbonate of Soda.*—The natural production of natron was ascribed by Berthollet to the action of carbonate of lime on common salt. But this reaction has never been demonstrated experimentally. It is known that calcium chloride, nitrate, and sulphate are decomposable by the bicarbonates and sesquicarbonates of soda as well as by the neutral carbonate. But even at ordinary temperatures the chloride of sodium is decomposed by the bicarbonate of magnesia, with the production of bicarbonate or sesquicarbonate of soda. The author's results explain the simultaneous occurrence of natron, and of the large quantity of magnesic chloride found in solution in salt lakes.

*Gallium.*—J. Regnauld.—The author has some years ago shown that according as a metal in alloying itself with mercury absorbs or liberates heat, it rises or falls in the scale of positive affinities. Zinc, *e. g.*, which in becoming amalgamated absorbs heat, is nearer to potassium than pure zinc, while cadmium, which in uniting with mercury liberates heat, is further from potassium. The analysis of the thermic conditions accompanying the double phenomenon of fusion and of combination between these simple similar bodies led the author to admit that the disposable chemical work which they possess is a function, not merely of the specific nature of their atoms, but also of the sum of the calories, which maintain them in a given physical state. To prove this view experimentally, he endeavored to form a hydro-electric couple, in which a liquid metal should be negative with relation to the same metal in the solid state. He has succeeded in constructing such a galvanic element with liquid and solid gallium connected by a stratum of a neutral aqueous solution of gallium sulphate. The liquid metal plays the part of zinc, and the solid that of copper.

*Starch.*—MM. Musculus and Gruber.—The following distinct compounds have been obtained from starch under the influence of diastase or of dilute boiling sulphuric acid: Soluble starch, erythrodextrin, achroodextrin $\alpha$, achroodextrin $\beta$, achroodextrin $\gamma$, maltose, and glucose.

*Quercite.*—L. Prunier.—Aqueous potassa has very little action upon quercite, even at 100°, but at about 200° to 250° a profound decomposition sets in. Among the products of decomposition are quinon, quinhydron, pyrogallic, oxalic, and malonic acids.

*Coloring Matter of Wines.*—Arm. Gautier.—The catechins (and their analogues, the quercetins), the tannins, and the vegetable coloring matters are closely connected together. It is possible to pass from the first to the last, as M. Gautier has ascertained by the limited oxidation of the catechins of gambir. The author endeavors to demonstrate these views as regards the coloring matters of wine, which are not identical, as has been supposed. Each kind of grape produces one or more special coloring matters, the totality of which forms a family of bodies, analogous but not identical, belonging to the aromatic series, playing the part of acids, partly in combination in the form of ferrous salts, and appearing to result from the oxidation of the corresponding tannins.

*Depolarization.*—M. Lippmann.—The depolarizing power of certain salts has long been known. The first constant current battery constructed in 1829 by M. Becquerel depends on the use of copper sulphate, while zinc and cadmium sulphates have been utilized by MM. Du Bois-Reymond and J. Regnault for the construction of impolarizable electrodes and of constant elements. This property, however, has not been studied. The author's experiments reveal an essential condition of the phenomenon. In order that an electrode may be depolarized it must be formed of the metal which is contained in the solution. Thus copper is the only metal which is depolarized in copper sulphate, while gold, silver, and platinum are polarized in this solution. On the other hand, copper is polarized in zinc and cobalt sulphates, etc. A salt depolarizes only its own metal. This principle may be applied to the detection of a metal in a solution. Taking, for example, copper: if a wire of this metal be plunged in a solution under examination, and taken as the negative electrode of a feeble current, it will not be polarized if the liquid contains 1-5000 of copper sulphate. The presence of copper may thus be detected in a mixture of metallic salts. With a silver wire silver may be detected in like manner.

*New Dielectric Constant.*—M. Neyreneuf.—On continuing the comparison of different isolating substances employed as the dielectric plates of a condenser, the author has established that for glasses of the same nature the ratio $\frac{e}{n}$ of the thickness to the number of sparks corresponding to a given quantity of electricity was constant. He has almost determined the value of this ratio for the varieties of glass met with in commerce. For substances much more isolating—such as ebonite, caoutchouc, and paraffine—the above ratio, which may be called the condensing constant, goes on increasing in a marked manner with the thickness. Consequently only results obtained with plates differing respectively little in thickness are comparable.

*Electro-magnets.*—E. Bisson.—The author has changed the manner, rolling the wire upon the coils of electro-magnets. At the end of each range he connects the wire in a straight line to the point of departure, in order to recommence the rolling from the same side as in the preceding ranges, and finds an advantage of one-third.

*Organized Dust in the Atmosphere.*—P. Miquel.—The author finds in his experiments that the number of organic cellules collected varies from 500 to 120,000 per cubic meter of air passed through his apparatus, not including bacteroid particles. Hence it is certain that the atmosphere contains at least a hundred times as many germs as was announced by Drs. Maddox and Cunningham. The author thinks that with more perfect apparatus the number he has obtained might be much exceeded. He finds that the number of microbia in the air is small in winter, augments rapidly in spring, remains almost stationary in summer, and decreases in autumn. Rain always occasions the recrudescence of these microbia.

*Aurin.*—R. S. Dale and C. Schorlemmer.—On the prolonged exposure of aurin to heat along with ammonia a base is obtained which has all the properties of rosanilin. As the formula proposed by the authors, $C_{20}H_{14}O_3$ (?), cannot be harmonized with Hofmann's formula for rosanilin, $C_{20}H_{19}N_3$, they endeavored to prepare a larger quantity of pure aurin in order to convert it into the base in question. The analysis of aurin prepared from pure phenol, as well as of that obtained by the purification of the commercial substance, give numbers which agree with the formula $C_{19}H_{14}O_3$. In the meantime they received a communication from E. and O. Fischer showing that the rosanilin prepared from paratoluydin has the formula $C_{19}H_{17}N_3$. They consider the rosanilin obtained from Messrs. Dale and Schorlemmer as identical with their own.

* See *Moderne Theorie der Chemie*, 3d Edition, p. 290.

*Flame Reaction of Boracic Acid.*—H. Gilm.—An equably colored splendid green flame is obtained by passing the vapors of boracic ether through a narrow tube into a wider vertical tube of glass, and burning it at the upper aperture, mixed with air.

*Hydroquinon-phthalein.*—A. G. Ekstrand.—The author, heating 1 mol. anhydrous phthalic acid with 2 mols. hydroquinon and from two to three times the weight of stannic chloride to 120° to 130° for twelve to fourteen hours, obtained a yield of 70 per cent. hydroquinon-phthalein. It is colored a deep violet by alkaline solutions, but on boiling or even on long standing it turns a dirty brown. In sulphuric and hydrochloric acid it dissolves with a red color. Diacetyl-phthalein is obtained by heating phthalein for two or three hours with anhydrous acetic acid.

*Oil of Lignite.*—C. Liebermann and O. Burg.—Lignite tar on distillation yields a mixture of hydrocarbons closely resembling those of coal-tar, containing 4 per cent. of benzol and toluol, and 0·9 per cent. of crude anthracen. Much gas is formed, especially from the portions boiling at the highest temperatures. Commercial petroleum suffered a very heavy loss by the formation of gas; it yields considerable quantities of benzol, but scarcely any anthracen. Technically speaking, the authors' experiments point to the possibility of utilizing the "gas-oil" of paraffine works—now produced in quantity and almost worthless—for the preparation of benzol, toluol, and anthracen.

*Brucin.*—R. Röhre.—If 1 part of brucin is treated with 25 parts of nitric acid of sp. gr. 1·4, and if the red solution is allowed to stand till it has become yellow, and is then mixed with stannous chloride in excess, the well-known deep violet coloration is produced, which soon passes into a dark red. On prolonged standing the liquid slowly becomes colorless, and well-formed violet crystals are deposited on the sides of the vessel. These crystals are soluble in water and mineral acids with a fine violet color, with the exception of nitric acid, in which they form a yellow solution. In potassa they dissolve with a greenish yellow color, which, on the addition of an acid, becomes violet. In alcohol they are sparingly soluble, and insoluble in ether, benzol, chloroform, petroleum ether, carbon disulphide, and amylic alcohol. The crystals contain no tin.

*Ortho-azo-benzoic Acid.*—A. Claus and F. Mallmann.—Pure ortho-nitro benzoic acid dissolves in potassa with an intense yellow color, and if sodium amalgam is added to such solutions the color becomes darker. If the addition of amalgam is continued so that a brisk evolution of hydrogen takes place, and if the mixture is well cooled, the pale yellow color returns. On the addition of acids reactions ensue, which vary greatly according to the circumstances. Thus if the warm solution immediately after the action of the amalgam is mixed with concentrated hydrochloric acid, brown or green solutions are obtained, which on boiling turn red or blue violet, and on cooling and standing deposit precipitates of a similar color.

*Cedriret.*—A. W. Hofmann.—The author having already recognized cedriret as a derivative of the dimethyl-ether of pyrogallic acid, has investigated the homologous cedrirets. He has digested pyrogallic acid, caustic potassa, and potassium ethyl-sulphate, with a large excess of absolute alcohol, for twenty-five to thirty hours in soda water bottles at a temperature of 100°, and has obtained various novel compounds, especially ethyl-cedriret, $C_{20}H_{14}O_6$.

*Dyes at the Exhibition.*—M. Poirrier exhibits violet de Paris, eosin, lutecienne, etc., in splendid specimens. M. J. Casthelaz, in addition to the ordinary coal-tar dyes, shows aureosin and rubeosinic acid. Bédlés, of Clichy, exhibits hexanitro-diphenylamin, diphenylamin, acetanilid, acetoluid, and toluydin in large white nacreous crystals. Among the most noteworthy objects is a collection of dichroic silk yarns, dyed with fluorescein, and displaying the beautiful fluorescence of this color.

*Alizarin.*—In order to distinguish artificial alizarin from extract of madder, Goppelsroeder sublimes the specimen and examines it with the microscope. All artificial alizarins contain, in addition to the long orange acicular crystals of alizarin, light yellow crystalline scales of anthraquinon. Or the specimen of dye is extracted with a concentrated solution of alum, the hot filtrate is allowed to cool, and filtered again after the bulk of the alizarin has been deposited. Extract of madder shows the well-known fluorescence of purpurin which is wanting in artificial alizarin.

*Tin Crystals.*—In order to determine the value of tin crystals, Goppelsroeder and Drechsel mix the hot solution with a known quantity of potassium chromate in solution. The stannous salt is thus converted into stannic, and it is merely necessary to determine how much chromic acid remains unreduced in the liquid in order to calculate how much stannous chloride was originally present. Chlorine is therefore liberated by the addition of hydrochloric acid, and conducted into a solution of potassium iodide, and the iodine liberated is finally titrated with sodium hyposulphite. To this process Dr. Reimann objects that commercial tin crystals invariably contain a certain proportion of stannic salt, which, if treated as above described, must escape valuation.

*Electric Light.*—At a meeting of the Société d'Encouragement, the Count du Moncel, on behalf of M. Regnier, exhibited improved points for the electric light. They are covered with a slender layer of nickel, which preserves them and concentrates the electric action toward the point.

*Vinegar Test.*—According to the *Archiv der Pharmacie*, genuine wine vinegars, if mixed with an equal volume of a solution of potassium dichromate, and boiled for about half a minute, turn a dark red, a change which occurs with no other vinegar. Wine vinegars also give a plentiful precipitate with plumbic acetate.

*Aniline Black.*—S. Grawitz.—The author's processes for dyeing these blacks consist in causing oxidizing salts or metallic acids to act upon an acid solution of aniline in presence of the tissues to be dyed. These become green, growing deeper and deeper, and finally black when the oxidation has reached a sufficient term, the bath remaining perfectly clear. He considers that in the formation of these blacks the metal plays a part totally different from what it fulfills in Lightfoot's process. In this latter the metal merely decomposes the chloric acid, which does not produce black, into lower stages of oxidation, which have that effect. In the Grawitz black, in spite of the acidity of the liquid, the metallic oxides obtained from the salts or acids employed are fixed upon the fiber in a true combination with the black, more intimate than in lakes, and very probably in a state of true substitution. One or more molecules of hydrogen are replaced by one or more molecules of the metal, which gives a special stability to the products of the ulterior oxidation by reason of the stability of the metallic oxides and of their affinity for oxygen. The author considers that his theory is fully proved by the following experiment, in which two stages can be traced, in the former of which the metallic acid has an oxidizing action, but in the latter a metallizing effect: Let a black be fixed with chromic acid acidulated with sulphuric acid. As soon as the tissue printed with a black capable of turning green has been worked for some minutes in a boiling bath containing a certain quantity of this mixture, the chromic acid is rapidly reduced, and the yellow liquor turns green. The reagents have therefore exhausted their oxidizing power, but the black still turns green on exposure to sulphurous acid. The amount of the reagents may be indefinitely increased, and the black may be rendered gray, or even destroyed, without affecting its property of turning green. But if, on the other hand, the tissue is worked in the bath with the original dose of chromic and sulphuric acids for half an hour or longer, the green liquor becomes a violet red, the black is fixed and is no longer capable of becoming green, and all the chromic oxide derived from the reduction of the chromic acid has disappeared from the liquid, and is found deposited upon the black portions of the cloth. [Has it been analytically proved that no chromic oxide remains in the liquid? To what is the violet-red color due?]

*On Brown Alizarin.*—M. Prud'homme.—This new product, if fixed with potassium ferricyanide or chromic acetate, gives light shades varying from a mode to a gray. The heavy shades seem difficult to obtain. With alkaline reducing agents brown alizarin gives a red liquor, which, on exposure to the air, becomes covered with a blue scum. The dye seems identical with that which may be obtained by an alkaline reduction of nitro-alizarin. If a solution of nitro-alizarin in caustic soda is heated for a long time in presence of a stannous salt, or of the hydrosulphite of soda, the color becomes successively violet, blue, red, and is covered with a blue scum. The new color may be useful along with the red and blue alizarins in substitution for dyes which require to be fixed with albumen.—*Bul. de la Soc. Ind. de Mulhouse.*

[Continued from SUPPLEMENT No. 139, page 2217.]

## THE PRODUCTS OF COMBUSTION.

By THOMAS WILLS, F. C. S.

THE air may be regarded as a mixture of nitrogen and oxygen in the proportion, in round numbers, of one-fifth of oxygen and four-fifths of nitrogen. But all ordinary air, the air which we find wherever we go, either at the top of a mountain or down in a valley, is always found to contain other bodies, and these bodies, some of them, are written here. Aqueous vapor is always present, carbonic acid also is always present in about this quantity—not invariably so, but very near it—and ammonia, which is rather more variable.

Now, of the two principal substances, this nitrogen is an exceedingly inert substance. It is with the greatest difficulty that it can be brought into union with other bodies directly, and in all processes of ordinary combustion the nitrogen remains entirely unacted upon. It takes no part whatever in such processes. On the other hand, the oxygen is an exceedingly energetic supporter of chemical action, and it is mainly, in fact entirely by virtue of this oxygen, which occurs in air, that air possesses its property of supporting combustion. Hence we should look for the products of combustion to be compounds of the constituents of the combustible body with this substance—oxygen gas.

Now such is, in fact, the case. The bodies which burn in an excess of air, as a general rule, form those compounds which contain the largest proportion of oxygen with which they can unite.

The carbon which exists in all our ordinary fuels burns to carbonic acid, which is the compound of carbon and oxygen containing the largest proportion of carbon.

The hydrogen in our illuminating fuels burns to form water, and water contains the highest amount of oxygen which we can unite with hydrogen under ordinary circumstances. Now the quantities of the products which we can form will depend on the weight of carbon and hydrogen which can be consumed in a given time. There is no loss whatever in these weights. Therefore the weights will be directly proportionate to the amounts which we are able to consume.

### QUANTITIES OF AIR REQUIRED IN COMBUSTION.

If we take 1 lb. of carbon, it will unite with 2·6 lbs. of oxygen, and will, therefore, form 3·6 lbs. of carbonic acid gas; 1 lb. of hydrogen will unite with 8 lbs. of oxygen, and will form therewith 9 lbs. of water. Now these quantities of oxygen will be found in the following quantities of air. Air consists of about one-fifth of its volume of oxygen, and the 2·6 lbs. of oxygen which are required for the combustion of 1 lb. of carbon will be found in 11·6 lbs. of air, or 150 cubic feet. In other words, 1 lb. of carbon will require all the oxygen contained in 150 cubic feet. The 8 lbs. of oxygen required to burn 1 lb. of hydrogen are contained in 34·8 lbs. of air, or 452 cubic feet—that is to say, there will be required for the combustion of 1 lb. of hydrogen the amount of oxygen contained in 452 cubic feet.

### ILLUMINATING FUELS.

With these remarks I may go on at once to the consideration of the combustion of four of our principal illuminating fuels. Two of them I shall deal with a little in detail; and, with regard to the others, I shall give you the position which they occupy relatively to the other two. These four will be—first, sperm in the form of candles; second, sperm or colza oil; third, paraffine oil; and, fourth, coal gas.

### CANDLES.

In spermaceti we have a compound of carbon, hydrogen, and oxygen. One pound of spermaceti contains 0·8 of carbon, 0·13 of hydrogen, and 0·06 of oxygen. If we burn a sperm candle at the rate of 120 grains per hour, the candle will give, per hour, 0·41 of a cubic foot of carbonic acid—not quite half a foot. If we take 16 candles burning for an hour, 6·5 cubic feet of carbonic acid are the product of the burning of the carbon contained in this quantity of spermaceti. If we consider the hydrogen which is contained in spermaceti, and regard the amount of water which is formed, we shall find that 120 grains of spermaceti burnt as in an ordinary candle will give 145 grains of water, 16 candles in one hour will give about 2320 grains, or 4½ ozs. of water. To put it in another way—a sperm candle, which may be regarded as weighing about 2¾ ozs., will give in its combustion 3¼ ozs. of water. This water will remain suspended in the air as aqueous vapor until the air is saturated. The amount of water which can be suspended in ordinary air is a question of temperature, and the amount becomes greater as the temperature is higher. But when the limit is reached, when the air contains as much water as it can take up at a given temperature, any further quantity must be deposited.

### SPERM OILS.

If we pass from candles to sperm oil, we find that colza oil and sperm oil, in respect to the amounts of carbonic acid and of water which they give, light for light, will be about equal. Paraffine oil is intermediate; it does not give off so much carbonic acid as do candles, but it gives off more, light for light, than coal gas. So also with the amount of water. The order in which these combustibles vitiate the atmosphere may be taken, as regards carbonic acid and water, thus: Light for light, coal gas, the lowest, represented by 1; paraffine oil, the next, 1·5; sperm candles, the worst, represented by 2—that is to say, the amount of carbonic acid and water given off by the combustion of sperm candles, light for light, compared with gas, would be about twice as much as that of coal gas.

### COAL GAS.

Now, for coal gas itself. If you take a specimen of coal gas which has a specific gravity one-half that of air, or 0·5, a cubic foot of such gas contains about half its weight of carbon; and, if this cubic foot of gas be burnt, it will give a little more than half a cubic foot of carbonic acid. The precise number is 0·55, or, in weight, 488 grains. With regard to the hydrogen, a cubic foot of coal gas, of 0·5 specific gravity, contains about 41 grains of hydrogen, and this hydrogen in burning will produce 372 grains of water. If we regard the quantity of air necessary to supply the requisite quantity of oxygen to a cubic foot of gas, it lies between 5 and 6 feet of air. For every cubic foot of gas burnt we require the entire oxygen of between 5 and 6 cubic feet of air, and this will give half a cubic foot of carbonic acid as a result. If we compare this with the amount of carbonic acid given off by respiration, we obtain the following relation: If 5 cubic feet of gas are burnt in one hour, we get from them 2·7 feet, or rather more, carbonic acid. If an adult human being breathes for the same period of time he exhales with his breath about 0·7 cubic foot of carbonic acid, about one-fourth of that given off by a gas-burner burning 5 cubic feet of gas.

### QUANTITIES OF CARBONIC ACID AND WATER PRODUCED BY COMBUSTION OF GAS.

Now the quantities of carbonic acid and water given off by one cubic foot, or even five cubic feet, appear relatively small; but if we come to deal with the quantity of gas used, say, in London annually, the amounts are somewhat astonishing—the figures are really startling. The quantity of gas consumed in London annually may be taken approximately, at present, at about 15 millions of cubic feet. The amount of carbonic acid given off during a year by the combustion of those 15 millions of cubic feet amounts to 433,000 tons. That quantity is discharged into the atmosphere by the combustion of the coal gas consumed in London, an amount which contains as much carbon as would be found in the wood growing in a forest of considerable dimensions. The amount of water produced by the combustion of this quantity of coal gas is 360,000 tons, or 80 million gallons. You will have on Thursday, I believe, an opportunity of seeing one of the largest if not the largest gasholder-tank in London, at the Phœnix works at Kennington. That gasholder-tank, supposing it had no internal cone, and were perfectly flat at the bottom, would hold—Mr. Woodall, your President, was good enough to calculate the figure for me—ten million gallons of water, if filled to the brim. You might empty that tank and fill it eight times over in a year with the water produced by the burning of the coal gas consumed in the Metropolis during that time.

### VITIATION OF AIR BY GAS COMBUSTION AND BREATHING.

Now we have to consider the effect of these results upon the vitiation of the atmosphere. The amount of carbonic acid in the air, ordinary normal air, is 0·04 per cent.; in other words, 4 volumes of carbonic acid are contained in 10,000 volumes of air. Now, if we increase this proportion to 0·06, we arrive at what may be set down as the healthy limit, and we ought not to go beyond it; in other words, 6 volumes of carbonic acid in 10,000 of air. As a matter of fact, even in our best buildings it is found under present circumstances almost impossible to keep the carbonic acid even as low as that, and for the purpose of calculation I am going to take as much as 0·1. Now, 0·1 per cent., or 10 volumes in 10,000 cubic ft., means this—that you may introduce into 10,000 cubic ft. of air the difference between 4 cubic ft. and 10 cubic ft. before you arrive at this amount of vitiation. In other words, you may discharge into 10,000 cubic feet of air 6 cubic feet of carbonic acid. You then reach the limit, which, as I say, is really beyond a healthy limit, for an atmosphere containing 0·1 of carbonic acid is a bad atmosphere, and anything beyond it is excessively bad.

Now 5 cubic feet of gas burnt will give off 2·75 cubic feet of carbonic acid, and the amount of air into which this amount of carbonic acid may be discharged, in order not to exceed the limit of 0·1 per cent., will be 4,500 cubic feet; in other words, for the combustion of 5 cubic feet of gas we require the specia. use of 4,500 cubic feet of air, supposing the air is not changed. One adult human being discharges by respiration 0·7 cubic foot of carbonic acid per hour, and the quantity of air which he will require the use of, in order not to exceed the limit of 0·1 per cent., will be 1,166 feet. So that if we start with a room of 5,660 cubic feet capacity, then we may allow a gas-burner to consume 5 feet of gas in that space and an adult human being to breathe for one hour before we reach the limit. But when we have once reached that point, where all the air is so far vitiated, it must either be renewed entirely or the vitiating influence must be put an end to.

### VENTILATION.

Now take the room in which we are assembled. This large room contains, in round numbers, 60,000 cubic feet of air. The external air may be taken to have the normal amount of carbonic acid in it of 0·04. We may, then, vitiate with impunity, that is without passing beyond this limit of 0·1 per cent. of carbonic acid, up to that extent. Thus we may introduce into this room 36 cubic feet of carbonic acid before we shall reach the limit of 0·1 per cent., supposing the air in the room not to be changed. Now, if 10 gas burners, each burning 5 cubic feet of gas, were burnt in this room for one hour, and 10 men remained in the room for the same period, these 36 cubic feet would be given off; in other words, 10 gas-burners burning 5 cubic feet each, and 10 men breathing for an hour, would bring up the proportion of carbonic acid in this room to 0·1 per cent., or outside the limit of anything which can be conceived to be a healthy

state of things. Now it is not at all an unusual circumstance for 25 gas-burners and for 100 men, as we are to-night, to be assembled in such a room, and if we take these figures, we shall require for combustion the use of 112,500 cubic feet per hour, and for respiration 116,500 cubic feet—both together being 229,000 cubic feet of air required for these purposes alone—in order that we shall not exceed that limit. In other words, the entire contents of this room must be changed four times in the hour to keep down the proportion of carbonic acid to the limit of 0·1 per cent., or 169,000 cubic feet of air must pass into and out of the room every hour in order that this shall not be the case. Now any current of air that travels at the rate of more than 16 inches per second is a draught; and it is obvious, from this fact, that the air in this room cannot be changed by any such forcible means. Direct currents of incoming and outgoing air do not, by any means, represent the amount of change going on.

### IMPERCEPTIBLE VENTILATION.

There is a process of diffusion taking place constantly through the walls and the ceiling and floors of our dwellings, and this process, although not recognized, and although continuing its action in silence, is an exceedingly important one, and is really a saving process for us who have to live occasionally in rooms not artificially ventilated.

### CURIOUS ILLUSTRATIONS.

The process of diffusion may be stated to consist in the tendency which all gases have to become intimately and permanently mixed; and the process goes on through porous substances, and through other substances which we do not usually regard as porous. I may illustrate the matter to you by a very simple experiment. I have here a tube closed at the upper end by a block of gypsum or plaster of Paris a little more than a quarter of an inch thick, and this glass tube is in communication with this upper receiver. I shall fill the tube with hydrogen gas, and I will place the lower end under the surface of some colored water. The inner part of the tube will be filled with hydrogen, outside will be air. The hydrogen will diffuse or tend to pass through the pores of the plug into the surrounding air, but the hydrogen will pass through faster than the air enters, and the consequences will be that a reduction of pressure will be caused inside the tube. If this be so, the column of water will rise, which will show you the effect. It is now filled with hydrogen gas; I immerse it in the colored water; we will leave it for a few moments, when you will find the colored water will rise in the tube. This means that there must be less pressure inside the tube than there is on the surface of the water, and this is due to the fact that the hydrogen is escaping through the pores of the plug faster than the air is entering. This is an illustration of the same process that is going on through our walls and ceiling.

### BUILDING MATERIALS AS RELATED TO VENTILATION.

Now the rate of diffusion varies inversely as the square root of the density. Its rate is dependent, therefore, on the density, so that any means by which we can alter the density of our air or gas will produce an effect on its diffusion. If you have two gases, one on one side of the porous plug and one on the other, the greater the difference in the density the greater will be the speed of diffusion. Now there are two things which tend to alter the density of air within our buildings; those two are—first, an alteration in the composition which takes place in the air; and, secondly, the elevation of the atmosphere. Now the alteration in the composition comes from the discharge into air of water and of carbonic acid; but the alteration is small, and may, as far as regards its influence or diffusion, be neglected. The elevation of temperature comes from the heat of our combustible fuels, and also from the heat of our bodies, and the greater the difference of temperature which we can get between the air inside and out, the greater will be the speed of this diffusion. But we shall find that as the rate of diffusion does not increase proportionately to the vitiation, we shall gradually overtake the rate at which it is taking place. Consequently we shall, after a short time, arrive at a limit beyond which the process of diffusion will be unable to help us, and from which point we shall begin to vitiate our air more and more. The heating effect of gas and of sperm oil is about equal, light for light; the heating effect of paraffine oil and candles is about the same, but greater than coal gas and sperm oil.

Of the materials which can be classed as ordinary building materials, those which permit the diffusion to go on most rapidly are: First, the material which is occasionally used, I am afraid, in the building of some of the houses in the suburbs—I refer to dried mud. That is a substance through which diffusion takes place with the greatest ease, much greater than through ordinary bricks or stones. Next to mud come bricks. Bricks allow diffusion to go on with a very considerable amount of rapidity and ease, almost as easily—easier in some cases—than through this plug of gypsum. You can see the ease with which the hydrogen finds its way through by the height to which the water has risen, representing 16 or 18 inches water pressure. Next to brick we have limestone. And, lastly, sandstone. This is the order in which you can take building materials. I would state here that, in my opinion, it is high time that architects and builders should be called upon to recognize that it is absolutely necessary to ventilate not only large buildings, but every room in a house in which persons may have to remain for some time, more especially those in which artificial illumination is used. If it were not for this process of diffusion, the matter would long ago have become imperative, because there would hardly be a room in which, after a little time, it would be possible to live; but so long as this condition is not arrived at, all concerned seem willing to allow things to remain much as they are.

### ENORMOUS QUANTITIES OF AIR REQUIRED TO VENTILATE COAL MINES.

The process of diffusion, although it has been a saving element in this matter, has been, at the same time, rather a snare, because when we lose its influence we find it becomes absolutely imperative to get air in some other way. When we descend a coal mine, we have no diffusion whatever to help us, and all the air which is required there for the respiration of men employed, and for the combustion of their illuminating fuels, must be sent directly down the shaft; and what is the consequence? That an enormous quantity is found to be required, much more than is conceived to be necessary on the surface—much more than is necessary, in fact. As much, in some of the northern pits, as 350,000 cubic feet of air is sent down per minute. This is needed, because they are not able to rely upon any other source below.

### DANGERS OF ORGANIC MATTER IN BADLY VENTILATED ROOMS.

The air of a room cannot be conveniently changed more frequently than from three to four times per hour, and it should be seen always that the vitiating influence is not in excess of this rate of diffusion. Further, the oppressiveness of a room, the effect which it has of producing headache and nausea, is not due only to the presence of carbonic acid and moisture. You may go into a soda-water manufactory, in which there is a very much larger amount of carbonic acid in the air than in any of our rooms which are even imperfectly ventilated, and you do not suffer in the same way as you do from remaining in an ordinary ill-ventilated room. The reason of that greater oppressiveness of our rooms is due to the presence, I think, of organic matter. Now, this organic matter is exhaled in the breath, and is given off by all our illuminating fuels; and it is this organic matter in the air which produces the feeling of depression which we all feel on remaining for some time in a room which is ill-ventilated. The amount of unburnt carbon products given off by coal gas, for example, is very large, and it is very probable that those burners which give out the greatest amount of light really give out the greatest amount of unburnt carbon products into the air. The amount of organic matter in the air will be proportionate to the amount of carbonic acid discharged either by respiration or combustion, and hence it may fairly be taken as a measure of the badness of the air.

### SULPHUR IN COAL GAS.

I have purposely omitted, up to this point, all mention of the sulphur which coal gas contains, and which, as an illuminating agent, is peculiar in this respect. I propose, with your permission, to detain you a few moments, while I deal with the subject of sulphur in coal gas. In any considerations of the vitiation of air by the products of the combustion of coal gas this sulphur must be taken into account. It occurs in the gas, in some form of combination, as most of you know, I apprehend, in some other form than that of sulphureted hydrogen. Undoubtedly, some part of it occurs there as bisulphide of carbon; but I do not think, by any means, that the amount of bisulphide of carbon accounts for the whole of the sulphur. In some cases, I believe, it accounts for a very small portion of it. But whatever form the sulphur may be in, when the gas is burnt that sulphur burns into sulphurous acid. There is a very considerable difference of opinion as to the precise state in which the sulphur is introduced into the air, some gentlemen affirming that it is sulphurous acid, others that it is immediately oxidized to sulphuric acid, and some, indeed, maintain that sulphuric acid is the product of the combustion of sulphur when it is burnt at the same time with hydrogen; that is to say, that when water is formed at the same time, sulphuric acid results, and not sulphurous acid.

### SULPHUROUS ACID

My own decided opinion is that the sulphur is at first all burnt to sulphurous acid, that then a certain portion of this sulphurous acid is oxidized into sulphuric acid, and that the amount so oxidized depends upon circumstances; but that given a sufficient length of time, the whole of the sulphurous acid will be oxidized into sulphuric acid. Now as to the circumstances. If the sulphurous acid is kept hot in the presence of moisture, then oxidation goes on more rapidly; if it be cooled down almost immediately after it is formed, the action is very slow, and within any reasonable time it will be found impossible to entirely oxidize the whole of the sulphurous acid into sulphuric acid. Then, secondly, if the sulphurous acid meets with a base or with an easily-oxidizable substance with which it can unite, it undergoes oxidation much more readily than if it remains in the state of free acid.

### METALS, BOOK BINDINGS, ETC., INJURED BY GAS.

There is no doubt that metal fittings, if used in contact with the products of combustion from coal gas, do become corroded with sulphuric acid. Here is some sulphate of zinc, which I myself obtained by burning London coal gas under a small zinc hood. You can also obtain sulphate of copper by burning coal gas, as most of us chemists know, under the surface of a copper water bath. There is no doubt whatever of this, but then we are dealing with this circumstance which I have mentioned; we have an easily-oxidizable substance present, a body which can unite with sulphurous acid and form a salt, and, under these circumstances, oxidation goes on very much more readily than otherwise. Thirdly, if sulphurous acid, water, and air be absorbed into a porous body, then oxidation goes on more rapidly, because the air and the sulphurous acid and the water are brought into closer contact, and I believe this is why leather bindings and leather goods generally are always brought so prominently to the front with regard to the matter of contamination by the combustion of the sulphur compounds in coal gas. It is due to the fact that you are dealing with a very porous substance, and the same thing being repeated again and again, you do in time get a certain amount of damage produced; but that this damage is anything like what is generally represented, I beg leave very much to doubt. From my own experiments, I believe that, under ordinary circumstances, considerably less than one-half of the sulphurous acid produced by the combustion of coal gas is oxidized in any reasonable time into sulphuric acid, and in this I am supported by several gentlemen, who not being connected with the coal gas industry, are, nevertheless, thoroughly acquainted with the behavior of sulphurous acid when used in the manufacture of alkali.

### SULPHUR IN GAS.

With regard to the question of sulphur in gas. You remember we concluded a short time ago that the air of a room must be constantly changed, or we could not exist, and that the change must be going on several times in each hour; the whole atmosphere must be changed generally more than three times in each hour. Now, supposing sulphur is burned into sulphurous acid, and that it exists for even a part of an hour as such in the air uncondensed, it will come under the ventilating effect, and will undergo removal just in the same way as the aqueous vapor or the carbonic acid present in the air. If one-half of the sulphur remains in the gaseous condition for only one hour, it will be entirely removed within that period. I believe most of the ordinary effects which are attributed to the presence of sulphur in coal gas, and the damage that it does, are quite easily accounted for by other things. I believe the constant drying and wetting, coupled with the elevation of temperature, and the presence of carbonic acid—effects which result from all illuminating fuels alike—are quite competent to account for the greater amount of the damage which is represented as being solely due to the presence of sulphur. If we regard the absolute quantity, the figures become exceedingly minute, even if you have 20 grains of sulphur in 100 feet of gas. Supposing it to exist in the form of bisulphide of carbon, here is such a quantity of bisulphide containing 20 grains of sulphur. The quantity in this little tube, about an inch of it, represents 20 grains of sulphur, or the amount which we may take as being present in 100 cubic feet of our London gas. Now, I could, if I had time, burn the whole of this quantity at once, and you would have all the sulphurous acid from it discharged into the air, and that would represent the sulphurous acid from 100 cubic feet, but I believe it would be impossible for you to find out the sulphurous acid, although it is there. Undoubtedly it is there, but it is diluted to such an extent that you could not find it by any ordinary test. If 20 grains of sulphur burn, they form 40 grains of sulphurous acid; a cubic foot of sulphurous acid would weigh 1,184 grains. Now the thirtieth part of a cubic foot of sulphurous acid is produced by 20 grains of sulphur, or the amount in 100 cubic feet of gas, and I may say that such a quantity in this room, supposing the room to contain approximately 60,000 cubic feet, would be represented by the block I hold in my hand, about 3¾ inch cube, and which, if diffused through the entire room, would amount to about one-half part per million in volume, or about 0·000001 per cent. in weight. If a proper arrangement were adopted to carry off the products of combustion, there would be no more complaints of sulphurous acid, and I believe that proper care ought always to be taken that coal gas ought not to be burnt, in anything like quantity, without such arrangements being adopted. If this were done, all danger from damage by sulphur, even if it existed in greater quantity than it does, would be at an end; but I expect it would be found, supposing you could find out how to take the whole of the sulphur out, the complaint of the damaging effects would continue for some time just the same.

I may say, with regard to the percentage, it has been found that in the Manchester atmosphere, over a range of four miles, the amount of sulphur present normally in the air would be about equal to the quantity which would be formed in this room by the presence in it of this amount of sulphurous acid; consequently, the whole atmosphere of that town we should expect to be doing damage by sulphur. If we regard the amount of coal burnt here in London, 8,000,000 tons per annum, and if we take that coal to contain 1 per cent. of sulphur which is burnt—whether in the form in which you send it into houses in gas, or in furnaces, or in grates, it is burnt in some way—and which is a low average, we shall have 80,000 tons of sulphur thrown into the air in the form of sulphurous acid, and if that is calculated into oil of vitriol, it will amount in one year to 240,000 tons of oil of vitriol sent into the atmosphere of London alone by the combustion of coal.

## COMPOSITION OF POTATOES.

AT a recent meeting of the Scientific Committee, Royal Horticultural Society, London, Dr. Gilbert made some very interesting remarks on this subject. He said that Mr. Lawes and himself had been for two years experimenting on the effects of different manures on the potato, and they had obtained a variation in the amount of produce from something over three tons without manure to nearly nine tons with the highest manure. Samples of the different crops had been analyzed in the usual way, and a great difference in the composition of the tubers was found. There was a difference of several units per cent. in the amount of dry or solid matter; there was about one and a third time as much mineral matter in some as in others; and there was nearly twice as much nitrogen in some as in others.

It occurred to them that it would be interesting also to examine the tubers somewhat in the way adopted in the case of some root crops, such as sugar-beet, that is, to express and determine the composition of the juice.

It was found that by far the largest proportion of both the mineral matter and the nitrogen of the tuber existed in the clear filtered juice, and there was as striking a variation in the percentage of these in the juice as in the whole tubers, depending on the character of the manure and on the amount of crop. It was remarkable, too, that some of the largest crops, which, judging from the withered condition of the tops, must be considered fairly ripe, nevertheless contained a juice relatively very rich in nitrogen.

His special object in referring to these experiments was, however, to call the attention of the Committee to some results which they had obtained with diseased potatoes. Already the Rev. J. H Jellett had examined the juice, or rather the extract, of sound potatoes, of the apparently sound part of diseased potatoes, and of the discolored part of diseased potatoes. He had found a considerable development of sugar in the white part of the diseased tubers. He also determined the amount of nitrogen in the dry matter of similar specimens, and found it to be greater in that of the apparently sound part of diseased potatoes than in that of sound potatoes, and also greater in the diseased part, but not so great as in the apparently sound part.

At Rothamsted they had experimented rather differently. They had determined the nitrogen and the mineral matter in the sound whole tubers and in the diseased whole tubers, in the juice of the sound potatoes, in that of the white part of the diseased potatoes, and in that of the black part of the diseased potatoes. They had also determined them in the washed or exhausted solid matter or "mark" of the white part and of the black part of diseased tubers.

In accordance with Prof. Jellett's results they found a higher percentage of nitrogen in the dry substance of the diseased than of the sound potatoes, but, calculating the quantity from the fresh tubers, they did not find evidence that there was an actually greater amount of nitrogen in the diseased potatoes.

The most interesting point in their results was, however, that while the juice of the white portion of the diseased potatoes contained approximately the same amount of nitrogen as that of corresponding sound potatoes, the juice of the diseased portion contained very much less—in fact, only about one-half or two-thirds as much. On the other hand, the washed or exhausted "mark" of the white portion contained a very small amount of nitrogen, while that of the black or diseased portion contained very much more, in some cases four or five times as much, as the "mark" of the white portion. It was also found that the amount of mineral matter was much higher in the juice of the white than in that of the diseased portion, but much lower in the "mark" of the white than in that of the discolored portion. It was obvious from these facts that the juice had suffered exhaustion of much of both its nitrogen and its mineral matter in the development of the fungus. The sugar, itself the result of diseased action, probably also contributed to the same end.

## THE RIVERS PARANA AND URUGUAY.

By JOHN J. J. KYLE, National College, Buenos Ayres.

FOR some years I have had occasion to analyze the water supplied to the city of Buenos Ayres, and in the year 1872 was employed to examine the water of the Rio de la Plata and of the River Parana, its principal tributary. The object of the latter investigation was to determine the most suitable locality whence to draw the increased supply which forms part of the City of Buenos Ayres Improvement Scheme, now being carried out under the direction of the eminent engineer, Mr. J. F. Bateman, F.R.S. I have very recently had an opportunity of analyzing the water of the other great river, the Uruguay, which, together with the Parana, supplies the enormous volume of water, estimated at 700,000 cubic feet per second of time, which the Rio de la Plata pours into the Atlantic Ocean.

I have not been able to find any reference to the composition of these great South American rivers in any of the standard works on chemistry, and for this reason I take the present opportunity of communicating a few particulars which appear to be of some interest.

The Rio de la Plata, or River Plate, is in reality the estuary of the Rivers Parana and Uruguay, is characterized by its muddy appearance, and always contains in suspension a considerable amount of "colloid" clay. This suspended clay is almost exclusively derived from the immense territory drained by the River Parana. The Uruguay is a river remarkable for its transparency and freedom from suspended matters. The following table shows the proportion and composition of the residue yielded by 1,000 c.c. of each of the three waters—the River Plate, at about five miles above the city of Buenos Ayres, the Parana, at about five miles above its termination in the Plate, and the Uruguay, in the middle of its stream in front of the town of Salto in the Republic of Uruguay:

| | River Plate. Grm. | River Parana. Grm. | River Uruguay. Grm. |
|---|---|---|---|
| Sodic oxide | 0·0212 | 0·0189 | 0·0020 |
| Potassic oxide | 0·0034 | 0·0046 | 0·0015 |
| Calcic oxide | 0·0078 | 0·0095 | 0·0055 |
| Magnesic oxide | 0·0050 | 0·0043 | 0·0019 |
| Ferric oxide | 0·0040 | 0·0030 | — |
| Aluminic oxide | 0·0060 | 0·0030 | — |
| Silicic acid ($SiO_2$) | 0·0193 | 0·0194 | 0·0185 |
| Sulphuric acid ($SO_3$) | 0·0058 | 0·0079 | 0·0013 |
| Carbonic acid ($CO_2$) | 0·0116 | 0·0122 | 0·0071 |
| Chlorine | 0·0114 | 0·0149 | 0·000247 |
| Nitric acid ($N_2O_5$) | — | — | 0·0019 |
| Organic matters | 0·0100? | 0·0106? | traces. |
| | 0·1055 | 0·1083 | 0·039947 |
| Determined directly | 0·1000 | 0·1000 | 0·039500 |

The three waters were examined by Wanklyn's process, and yielded per liter:

| | River Plate Mgrms. | River Parana Mgrms. | River. Uruguay. Mgrms. |
|---|---|---|---|
| Free ammonia | 0·07 | 0·16 | 0·07 |
| Albuminoid ammonia | 0·24 | 0·24 | 0·10 |
| Hardness (1°=0·01 grm. per liter of $CaCO_3$) | 4·00° | 4·50° | 2·25° |

The minute quantities of nitric acid were not determined in the Plate and Parana waters; in the Uruguay water it was estimated by Thorpe's reduction method. Part of the silica and all the alumina belong to the clay which, as already stated, is suspended in the first two waters, and remains in this condition for many weeks. The water of both the Plate and Parana always yields, by Wanklyn's ammonia process, a very large amount of albuminoid ammonia, derived chiefly, I believe, from vegetable organic matters partly in solution and partly adherent to the suspended clay. In spite of this and its opaline, sometimes even muddy, appearance, the Plate water is highly esteemed as a drinking-water.

Beyond this the composition of these two rivers does not call for any further observations. The water of the River Uruguay is, however, in some respects very remarkable. It is probably one of the purest river waters in the world, containing rather less than 4 parts of solid matter per 100,000. It is almost free from chlorides; the determination of chlorine, made with every possible care, gave rather less than one-fourth of a milligrm. per liter, and this, be it remembered, at a distance of say five hundred miles from its source.

Still more noteworthy, in my opinion, is the fact that about 46 per cent. of the total solid matter consists of soluble silica, not suspended as in the other two rivers. A small proportion exists probably as alkaline silicate, but the greater part is undoubtedly present as hydrated silicic acid. In this circumstance may be found an explanation of the petrifying properties attributed to the water of the Uruguay. On one occasion a cart-wheel was fished up from its bed completely converted into stone. A considerable export trade in agates is carried on by the inhabitants on the Uruguayan shores of this great river, and the stones from the Uruguay are, I believe, those most esteemed by European lapidaries. The free silicic acid dissolved by this river among the mountains of Santa Catherina, in Brazil, is probably the raw material out of which are elaborated the agate mortars so invaluable to every analytical chemist.—*Chemical News.*

## VOLVOX GLOBATOR.

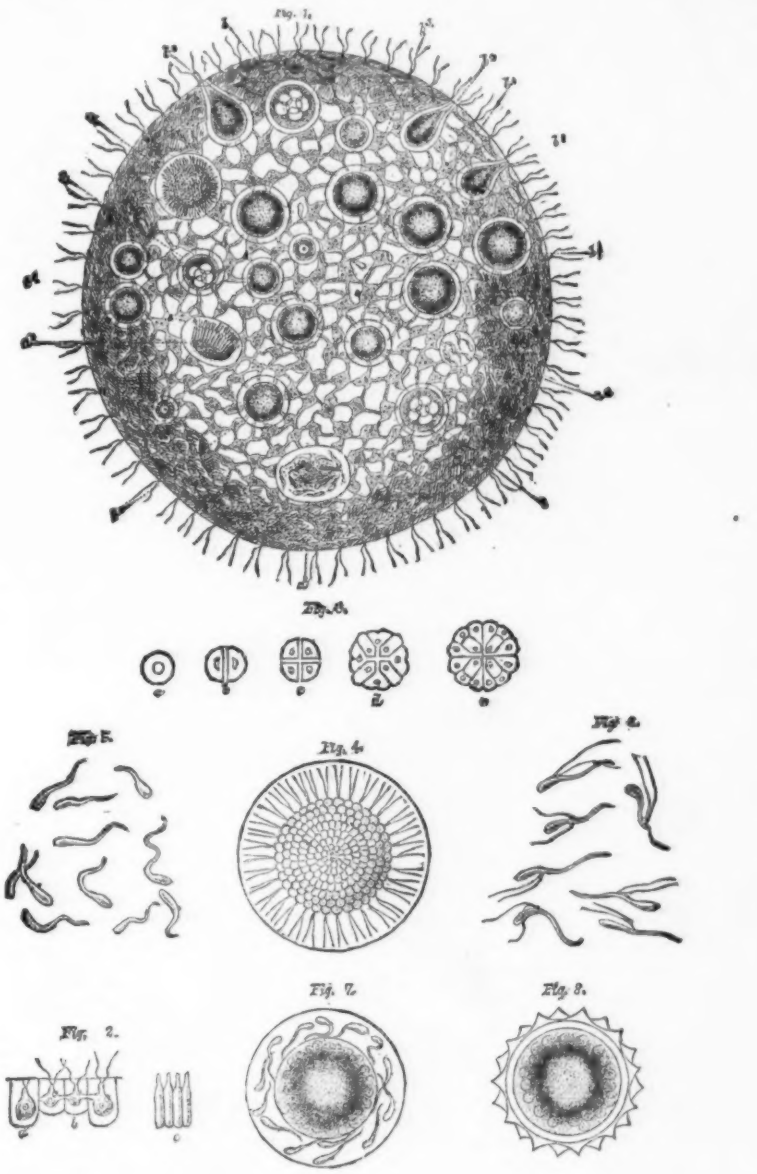
By ALFRED W. BENNETT, M.A., B.Sc., F.L.S.

THE organism which we are about to describe has long been a favorite object for observation to microscopists, not only from the extraordinary beauty and delicacy of its structure, but from the remarkable phenomenon which it presents of a member of the vegetable kingdom endowed with a power of motion apparently as spontaneous as that possessed by any organisms belonging to the animal kingdom. The very location of the *Volvox* among plants has indeed been challenged. Like many others which are now placed, by almost universal consent, among the lower classes of Cryptogams, it was held by the distinguished naturalist Ehrenberg to be of animal nature. If, however, any doubt remained as to its true vegetable character, this has been completely set at rest by the researches of Professor Cohn,* who has only quite recently for the first time followed out completely the various stages of reproduction of this singular organism. In no English work will they at present be found adequately described, although so many observers had before his time had it under their notice.

The *Volvox globator* is not uncommon in clear pools on commons, and in similar situations, and is visible to the naked eye as a minute pale-green globule rolling through the water, passing rapidly across the field of view under the microscope, its full diameter being perhaps $\frac{1}{16}$ of an inch. Under the microscope it is seen that the rotatory motion is caused by innumerable fine transparent vibratile cilia, with which the surface is studded. The appearance presented by the entire body is that of a globular, transparent, hollow membranous sac, through which these cilia protrude, and studded with bright green points, while in the interior are seen a small number of dense green globes. In the autumn or early winter these internal globes have often assumed an orange color, giving to the whole globule a red tinge. The vibratile cilia already described are arranged in pairs, each pair belonging to a separate peripheral corpuscle or cell. These peripheral cells contain each a green protoplasm-body, varying in shape according to the age of the individual, as shown in Fig. 2, *a*, *b*; they usually contain a minute starch-granule, a reddish-brown "eye-spot," analogous to that of swarm-cells (zoospores) and of the Flagellate Infusoria, and one or two contractile vacuoles, the cilia being borne at the narrow hyaline end. Each is surrounded by a gelatinous envelope, which is pierced by a number of canals, all lying nearly in one plane, and filled by green or colorless extensions of the protoplasmic interior. Since the canals of adjoining cells correspond, the corpuscles appear as if connected together by a network of fine reticulations. The outer gelatinous wall of each cell is also perforated by two pores, through which the two vibratile cilia protude into the surrounding water. They constitute a single peripheral layer enveloping the entire organism, corresponding to the plate which is characteristic of many Chroococcaceæ; each one by itself would be undistinguishable from an ordinary swarm-cell of many filamentous Algæ, or from the entire individual of *Chlamydococcus* or *Pleurococcus* in its motile stage. They have, however, so far as is known, no reproductive function, and in this respect stand almost alone among cells endowed with a spontaneous power of motion.

Besides these non-reproductive or sterile cells, there are in each *Volvox* colony three kinds of reproductive cells—non-sexual (neuter), male, and female. The neuter reproductive cells, or parthenogonidia, as Cohn terms them, are similar in structure to the sterile cells, but two or three times their size, *i. e.*, from 0·006 to 0·009 mm. in diameter. Very early in the development of the young colony they begin to multiply by bipartition, and all the cells in the same colony or sphere are usually at one time in the same stage of development. This division has been followed by Cohn through four stages, as shown in Fig. 3, *a–e*, the fourth stage consisting of sixteen cells, beyond which he was unable to trace it, owing to the difficulty of the observation. At this stage it is described as having somewhat the form of a blackberry, each segment possessing a single chlorophyl-granule containing starch. The young colony is surrounded by a transparent membrane, which it at length breaks through, and carries on an independent existence within the cavity of the mother-colony, each of its cells developing a pair of cilia; finally it escapes from its confinement in the mother-colony into the surrounding water. The normal number of parthenogonidia which thus develop into colonies within the mother-colony is eight, corresponding to the eight cells into which each of them breaks up on its third segmentation. The young colonies complete their growth in a few days, attaining a diameter of from 0·10 to 0·15 mm., and have by this time absorbed the greater part of the chlorophyl and starch of the mother-colony.

The sexual reproductive cells, male and female, are very few in proportion to the sterile cells. While the non-sexual reproduction by parthenogonidia takes place during the whole year, the sexual cells are apparently formed only in the autumn. The two kinds are found either in the same or in different colonies, establishing the classification of the genus into monœcious and diœcious sub-species, as first pointed out by Cohn. Fig. 1 represents a monœcious colony. The two modes of reproduction do not take place simultaneously in the same colony, the sexual generation forming the close of a longer or shorter series of non-sexual generations. *Volvox* presents, in fact, one of the earliest instances in the ascending series of the phenomenon known as alternation of generations, which attains its highest development in plants in the Vascular Cryptogams. The female cells (gynogonidia of Cohn) are at first undistinguishable from the parthenogonidia, but are much more numerous. On their first appearance they are about three times the size of the sterile cells; their protoplasm-body increases rapidly, and becomes of a dark green color from abundance of chlorophyl. They have at first a frothy appearance (Fig. 1, *b*) from the formation of vacuoles, but afterward appear to be filled with protoplasm; and they are now at once distinguishable from the parthenogonidia by their never dividing. They soon become flask-shaped (Fig. 1, $b^3$), their narrow end touching the periphery of the sphere, and the larger end hanging free into the cavity. When ready for impregnation they round themselves off into




VOLVOX GLOBATOR.

Fig. 1. A monœcious colony of *Volvox globator*—*a*, $a^3$, $a^5$, antheridia; *b*, $b^3$, gynogonidia; $b^3$, $b^4$, oospheres. Fig. 2. Ciliated peripheral cells. Fig. 3. *a–e*, Parthenogonidia in successive stages of division. Fig. 4. Complete antheridium. Figs. 5 and 6. Antherozoids. Fig. 7. Oosphere containing antherozoids (see also Fig. 1, $b^4$). Fig. 8. Fertilized oosphere. All the figures highly magnified.

* "Beitrage zur Biologie der Pflanzen," vol. i., heft 3, 1875.

a spherical form (Fig. 1, $b^2$), and may then be designated oospheres, each being enveloped in a gelatinous membrane or oogonium. The male cells, or androgonidia, present at first a still closer resemblance to the parthenogonidia, since, when they have attained about three times the size of the sterile cells, they begin to divide; but they are of a lighter color, from containing a smaller quantity of chlorophyl. The divisions also take place only in two instead of in three directions, thus developing, not into a sphere, but into a plate of cells. They ultimately resolve themselves into a bundle of naked primordial cells (Fig. 1, *a*), each consisting of a thicker but elongated body, in which the chlorophyl has been transformed into a reddish-yellow pigment, and of a long colorless beak, to the base of which are attached two very long vibratile cilia, and where also is a red corpuscle or eye-spot (see Figs. 4, 5, 6). The whole androgonidium may now be considered as an antheridium inclosed in a gelatinous envelope, each of the naked protoplasmic bodies being a motile antherozoid or spermatozoid. About the same time that the gynogonidia have matured into oogonia, and their protoplastic contents into oospheres, the movements of the vibratile cilia attached to the antherozoids begin to set the whole antheridium in motion, in the positions indicated in Fig. 1, *a*, $a^2$; the antheridium soon breaks up, and the separate antherozoids are seen in rapid independent motion within the gelatinous envelope of the antheridium (Fig. 1, $a^3$), which they ultimately break through, and then move about rapidly in all directions within the cavity of the mother-colony. Their movements are described by Cohn as being remarkably beautiful, the constant curvings of the elongated neck of the antherozoid being compared by him to those of the neck of a swan. They assemble in large numbers round the oogonia, and some of them finally penetrate through their gelatinous envelopes (Fig. 1, $b^4$, Fig. 7), and coalesce with their protoplasmic contents or oospheres. The fertilized oosphere is now a oospore, and develops a new cell-wall, the epispore, which is at first smooth, but afterward covered with conical elevations, giving a section of it a stellate appearance (Fig. 8). A second perfectly smooth membrane, the endospore, is subsequently formed within the first. The chlorophyl gradually disappears, and is replaced by an orange-red pigment dissolved in oil, so that the mature oospore, while still inclosed within the mother-colony, is of a bright red color, giving the red tinge which *Volvox* often presents, even to the naked eye, at certain periods of the year. Individuals containing oospores still enveloped in their spiny coatings were described by Ehrenberg as a distinct species, under the name of *V. stellatus*. The number of sexual reproductive cells in a colony of *Volvox* varies greatly; Cohn has observed five or more male and about forty female cells.

Soon after the oospore reaches maturity the mother-colony breaks up, single cells escaping from the combination and swimming about freely in the water; their further history is unknown; while the oospores fall to the bottom and there hibernate. Their further development has only been observed by Cienkowski, who states that the contents of each spore break up into eight spheres which ultimately swarm out.

Ehrenberg described two species of *Volvox*—*V. globator* and *V. stellatus*—both of which he considered to be infusorial animalcules. These have been determined by Cohn to be different stages of the same species, the former in its parthenogenetic, the latter in its sexually reproductive condition; Ehrenberg's *Spharosira volvox* is also another form of the same species. His *Volvox aureus* and Stein's *V. minor* are considered by Cohn to form a distinct sub-species of *V. globator*, differing from the typical form in the colonies being of a smaller size, and dicecious instead of monœcious, and in the epispore of the oospore being smooth. The mode of fertilization of the latter form has not yet been directly observed. The genus is cosmopolitan, having been found throughout Europe, in North Africa, India, and North America.

The old family of Volvocineæ, which included the genera *Volvox*, *Eudorina*, *Pandorina*, *Gonium*, and *Stephanosphæra*, is placed by Sachs, in the 4th edition of his "Lehrbuch," under the Zygosporeæ, and in the section characterized by the conjugation of zoogonidia (swarm-spores or zoospores). It is evident, however, that the family, as so constituted, cannot be maintained, and Rostafinski's classification must be accepted as preferable, retaining those genera which exhibit the conjugation of swarm-spores as a family of Zygosporeæ, under the name of Pandorineæ, while the true Volvocineæ are placed in the class of Oosporeæ,* in which the process of impregnation consists in the coalescence of one or more minute spontaneously motile antherozoids, which escape from an antheridium, with a comparatively large oosphere contained in an oogonium. The process indeed bears a very close analogy to the mode of fertilization in one of the highest families of Oosporeæ, the Fucaceæ. The family Volvocineæ, as thus constituted, includes at present only the two genera *Volvox* and *Eudorina*. The structure and developmental history of the latter have been described by Carter.†

## RESULTS OF THE RECENT ECLIPSE.

IN a letter to the New York *Times*, Prof. C. A. Young says:

It is early, as yet, to estimate the full scientific meaning and value of the observations made during the recent solar eclipse (July 29, 1878), but it is already evident that, though in some respects disappointing, they are yet, on the whole, of an importance quite equal to those obtained on any similar occasion.

One brilliant discovery will probably date from this occasion, and hold a conspicuous place in the annals of science. The planet Vulcan, after so long eluding the hunters, showing them from time to time only uncertain tracks and signs, appears at last to have been fairly run down and captured. At least it seems to us that the observations of Prof. Watson at Rawlins, and Swift at Denver, must for the present be taken as conclusive, though perhaps not settling the question beyond the possibility of reopening or dispute. The gentlemen are both astronomers of repute, accustomed to sweep for faint objects, and provided with excellent instruments. The negative results of Profs. Newcomb, Wheeler, Holden and others, who, with similar instruments, went over the same ground and found nothing, are, indeed, unsatisfactory and puzzling; but they can hardly outweigh the positive evidence on the other side, though they certainly justify a certain reserve in accepting the conclusion.

Assuming as correct Prof. Watson's estimate of the planet's brightness (four and a half magnitude), it would be more than forty times fainter than Mercury, and considering its proximity to the sun (which would make it much brighter than if at the same distance as Mercury), it would seem that its diameter must be somewhere between 200 and 400 miles. If really thus minute, it is easy to see how it has so long escaped discovery; indeed, the question at once arises whether there must not be several such Vulcans, to account for that peculiar behavior of Mercury, which led Leverrier, on purely mathematical grounds, to assert the existence of a planet or planets between Mercury and the sun. Mr. Swift, in fact, claims to have seen two bodies—Watson's and another near it.

It is unfortunate that the single observation of Prof. Watson cannot give definite information as to the orbit and motions of the planet; but for this purpose at least three observations are needed, and unless (as Prof. Watson hopes to do) he succeeds in identifying some of the many recorded transits of small black objects across the solar disk, as observations of his planet, it may be long before we shall know anything further about it. There is, however, a bare possibility that it may be recovered in full daylight by arming a large telescope with a very long tube, projecting beyond the object glass, and thus enabling the observer to examine the sky within a degree or two of the sun without letting the sunlight fall upon the lens. If the experiment could be tried at a considerable altitude, where the atmospheric glare is at a minimum, the chance of success would be greatly improved.

As regards the physics of the sun and the corona, the principal and most important result of all the observations bearing upon this subject is to demonstrate a decided sympathy and connection between the condition of the sun's visible surface, as indicated by the number and character of the sun's spots, and the constitution of the corona.

At the present time the sun's spots are at their minimum; whole months have passed without the appearance of a single one. The chromosphere, or colored envelope of hydrogen and other gases which immediately surrounds the sun, has also been correspondingly quiescent, and the so-called "prominences" have been few and small. Of course, it was a question of interest whether the corona also would show a corresponding difference of condition from that indicated in 1869 and the later eclipses, when the sun's surface was in full activity, and the question has received an emphatic and affirmative answer.

As to the brightness of the corona at the recent eclipse, there is considerable difference of opinion. The writer, and he thinks a large majority of those who also saw the eclipse of 1869, is strongly of the impression that in 1869 the corona, though perhaps less extensive, was many times more brilliant, while the corona in 1870 seemed to him intermediate between those of 1869 and 1878. Some of the best observers, however, are of quite the contrary opinion, and it is frankly to be admitted that one's judgment as to the brightness of an object like the corona depends so much upon the condition of the eye at the moment of observation, and that condition so depends upon what the eye has been doing for the last few moments preceding, that no very great weight is to be assigned to such impressions. The writer feels, however, considerable confidence in his estimate of the relative brightness of the three eclipses, because in all three cases his observations were made under almost precisely similar circumstances—near the middle of the eclipse, and after about a minute of close spectroscopic work.

While, however, there may be room to question the conclusion that the corona this year was uncommonly faint, there can be no question that its spectrum was profoundly modified.

The bright lines which come from its gaseous constituents were conspicuous in 1869 and in all the subsequent eclipses until the present one, but this year they were so faint as to be seen by only a few of the observers, while the great majority missed them entirely, seeing only a continuous spectrum. This was especially remarkable in the case of the green corona line (known as "1474" from its position upon Kirchhoff's map of the solar spectrum). Many observers saw it plainly just at the beginning and end of totality, but during the middle of the eclipse nearly all entirely lost sight of it. That it was really present all the time, however, though faint, is proved by the observations of Prof. Eastman, Mr. Thomas and the writer, the former of whom traced it all around the sun to a distance of from 10′ to 20′, going twice over the ground, and keeping it in sight all the time. With the hydrogen lines the case was similar; the writer had one or other of them in the field continually, and they never quite disappeared, though at times very faint.

Of course, the slitless spectroscopes, both ocular and photographic, from which so much had been expected, failed to give any satisfactory results. In 1871, when the instruments were first used, the observers saw a series of colored images of the corona. Mr. Lockyer, for instance, saw four such images, one red, one green, one blue, and one violet. This year nothing of the kind appeared. At the moment, indeed, when totality began there was an exquisite exhibition, first of the darkness of the solar spectrum, and then for an instant of a multitude of bright colored segments—the spectrum of the chromosphere; but when the moon had covered the chromosphere there was only a disappointing, continuous band of color, unmarked by rings of any kind.

Those, also, who were looking for new bright lines in the corona spectrum were equally unsuccessful, whether they employed the ordinary spectroscope or worked by photography. Some of the observers, the writer among others, used a so-called "fluorescent eye-piece," which brings the otherwise invisible light beyond the extreme violet end of the spectrum within the range of human eyes, by the action of a film of fluorescent liquid (æsculia solution) inclosed between thin plates of glass. But, although before totality the apparatus worked perfectly, disclosing to the eye dark lines innumerable in the portion of the spectrum invisible without its aid, after the darkness came on it failed to show a single bright line. The most carefully prepared and sensitive photographic apparatus succeeded no better, except that Dr. Draper, Mr. Lockyer, and one or two others perhaps, did obtain by means of a slitless spectroscope, an impression of a faint continuous spectrum in the ultra violet, without rings or markings of any kind. Evidently no lines existed to see or photograph on this occasion.

One or two observations were made of some interest in their relation to previous work. Prof. Rockwood, of the Princeton party, using a double-barreled slitless spectroscope, observed at the beginning of totality a bright red line in the chromosphere spectrum very near to B. This explains an observation of Mr. Pogson in 1868, who then insisted that he saw B reversed in the spectrum of a prominence, but as all the other observers had C instead of B, his record was generally regarded as a mistake.

The line is probably one well known to solar spectroscopists, at 534 of Kirchhoff's scale—a line exceedingly difficult to see in the spectrum of the chromosphere under ordinary circumstances, but still invariably present, and exhibitable (if one may coin a word) with proper appliances. Its conspicuousness in Prof. Rockwood's instrument is a matter of some surprise, but there could be no mistake, as C was even more brilliantly conspicuous at the same time. What the substance which causes it may be is quite unknown. Like the so-called Dz line, it has no corresponding dark line in the solar spectrum.

The same observer, and the writer also, saw both H lines (calcium) brightly reversed in the spectrum of the chromosphere; thus confirming observations made six years ago at Sherman, but never corroborated since, except by the photographic spectrum obtained by the Siam expedition in 1875.

The exquisite reversal of the dark Fraunhofer lines at the moment of totality was seen by many of the observers. One observer, at least (and we believe some others), Prof. Barker, at Rawlings, was able to confirm Janssen's observation in 1871 by seeing the principal dark Fraunhofer lines in the corona spectrum, thus showing that a considerable percentage of the coronal radiance is mere reflected sunlight. The dark lines were, however, so faint as to be seen by very few, and this shows equally clearly, we think, that the particles which reflected the sunlight are themselves also self-luminous, as, of course, they ought to be so near the sun.

A great deal of attention has been paid to the polarization of the coronal light in past eclipses, and while on the whole there has been an overwhelming weight of evidence in favor of radial polarization, yet at every eclipse some observer of reputation has obtained anomalous results quite at variance with all the others. This year Dr. Hastings, of Baltimore, comes out with strong tangential polarization as his result. That he must be the victim of some mistake is almost certain, since all the rest of the observers—Wright, Ranyard, Harkness and others—are emphatic and clear in their contrary conclusion.

Experiments with the tasimeter or new heat measure of Mr. Edison showed, as was ascertained many years ago, that the heat of the corona is quite sensible. With a thermopile attached to a peculiarly arranged spectroscope Mr. Anderson, of the Princeton party, obtained a doubtful result, which may indicate a bright heat-line in that part of the chromosphere spectrum below the red.

It has been represented in some quarters that the results of this eclipse require a fundamental reconstruction of the theories hitherto held regarding the constitution of the corona. This is, however, an entire misapprehension. The same constituents appear in the corona as hitherto, only in altered proportions, as might have been and was expected by students of solar physics. In 1869, 1870 and 1871 the gaseous elements of the corona—the hydrogen and "1474 stuff," whatever they may be—were in such quantity and condition and rose so high above the solar surface that their lines were conspicuous in the coronal spectrum, and attracted the attention of observers far more forcibly than the feeble continuous spectrum of the light emitted from and reflected by the minute solid or liquid particles which also constitute an essential element of the corona. At present the condition is reversed. The gases are either too small in quantity or too cool to be conspicuous. The lesson, and it is an important one, is simply, as has been said, that, to a certain extent, the corona sympathizes with the sun-spots.

It certainly looks probable, also, that while the gaseous elements of the corona are strictly solar, the non-gaseous matter—the coronal dust or haze—is of extraneous and very likely meteoric origin. At any rate, the extent of the corona was certainly not less than on former occasions, whatever may have been the case with its brightness. In fact, it has never been traced quite so far from the sun before as this time by Langley and Newcomb, who followed it out for 6° along the ecliptic, a success partly, of course, due to the clearness of the air at their elevated stations. Now, this is quite consistent with the theory that meteor streams furnish the hazy matter of the coronal envelope, since, so far as we can judge, they have nothing to do with sun-spots.

A very interesting problem relates to the effect of solar forces upon this meteoric matter, if such it really be, and the material for the study is furnished in rich abundance by the numerous drawings made by Langley, Abbe, Penrose, Boss, and others, and by the photographs, which in excellence and number excel those obtained on any previous occasion. Among the best which we have seen are the magnificent series made by Rogers at La Junta, those of Draper at Rawlins, and those of the Princeton party at Denver; undoubtedly there are others of at least equal excellence.

To sum up: The eclipse of 1878 has added a new planet to the system, and has demonstrated that the unknown cause, whatever it may be, which produces the periodical sun-spots at intervals of about eleven years, also affects the coronal atmosphere of the sun.

This undoubtedly adds a certain measure of probability to the idea that these solar periods may produce some effect upon the earth, such as may be felt in our meteorological conditions; and though the writer by no means concurs with Mr. Lockyer in considering that Meldrum's investigations upon Indian cyclones have already demonstrated connection between the sun-spots and the weather, but, on the other hand, thinks the connection almost disproved by results of other investigators, still there can be no question that the subject deserves thorough study.

The result of the late eclipse goes to show such a periodical change in the state of the solar atmosphere as might very possibly produce a sensible effect upon the earth; whether it does or not is a question which can be settled only by a careful and systematic investigation of the facts.

C. A. YOUNG.

Princeton, N. J., Thursday, Aug. 15, 1878.

## CURRANT WORMS.

M. B. BATEHAM of Ohio says he destroyed currant worms by the following application:

Having no soft-soap on hand, we took about one-fourth of a pound of hard soap, cut in slices and dissolved in warm water, then stirred in an ounce of crude carbolic acid (costing a dime), and stirred the whole into half a pailful of water. With this liquid we sprinkled the bushes, using a whisk broom, so as to wet all the worms visible. Scarce a live one could be found the next day.

G. WALKER proposes to make up an oil for painters by mixing linseed oil, or some other vegetable oil, with refined petroleum and fish-oil. The mixture is then to be heated with manganese.

* This is the course followed in McNab's recent class-book of botanical classification.

† "Annals of Natural History," 3d series, vol. ii., 1858, p. 327.